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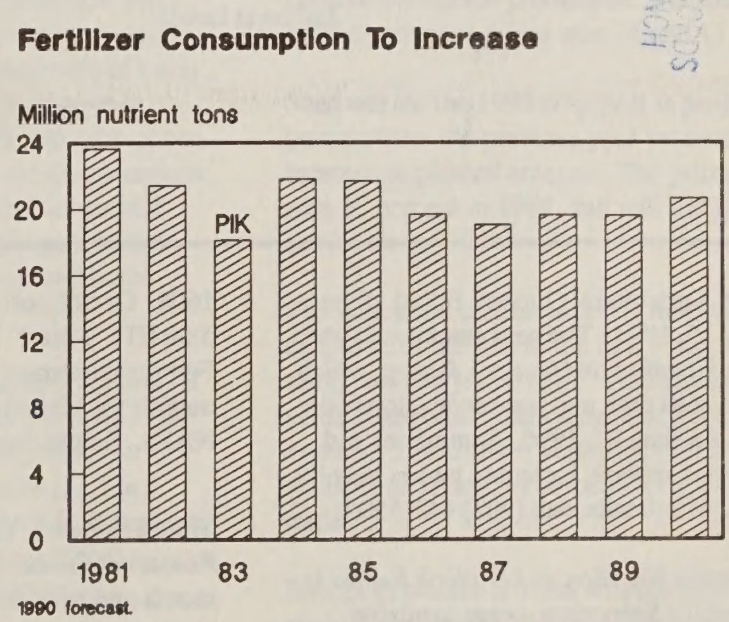

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Contents

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Summary

U.S. plant nutrient consumption from July 1989 to June 1990 is forecast to rise 5 percent from a year earlier because of expected gains in planted acreage of the major fertilizer-using crops and anticipated increases in application rates on corn, soybeans, and wheat. Use of nitrogen, phosphate, and potash will likely equal 11.2, 4.3, and 5.1 million tons, respectively. Planted area of corn and wheat, the major fertilizer-using crops, will probably increase by 1-5 percent. Decreases in planted acreage are anticipated for soybeans.

Spring 1990 fertilizer prices are expected to average 4 percent above October 1989, but may fall 4 percent short of year-earlier levels. Supplies of nitrogen, phosphate, and potash should meet 1990 crop needs. Greater nitrogen imports will more than make up for reductions in domestic production. Nitrogen prices will likely show the greatest increase since last fall as domestic supplies tighten. Phosphate supplies should be sufficient to meet demand at moderately higher prices than last fall, even with a slight reduction in domestic production. Potash supplies will be available at stable to slightly lower prices than last fall if the price cuts initiated by Canadian producers continue.

World plant nutrient use rose about 3 percent in 1988/89. Worldwide growth in fertilizer production, consumption, and trade will likely continue during the 1990's, tightening the supply and demand balance and placing upward pressure on world prices. Fertilizer production and consumption will probably climb only slightly in the developed market economies, but more in the developing market economies of Latin America and Asia. By the end of the 1990's, growth in world nitrogen demand could exceed supply and raise prices. Most developed countries will likely have surplus phosphate fertilizer, while the USSR, Asia, and Eastern Europe will have deficits. North America will have the largest potash supplies, while Western Europe, Asia, Africa, and Latin America are projected to have deficits.

Pesticide use on major field crops in 1990 is forecast to total 470 million pounds of active ingredients, up 2 percent from 1989. Spring 1990 herbicide and insecticide prices are expected to be up 3 percent and fungicide prices, 1.5 percent. These increases come on the heels of a 3-5 percent rise in 1989. Overall domestic availability of pesticides is expected to equal that of 1989, but should still meet expanded consumption.

Concerns over water quality, food safety, and potential environmental damage (such as bird kills) have prompted the Environmental Protection Agency (EPA) to consider regulatory action. The EPA has proposed restricting use of EBDC fungicides and carbofuran, an insecticide.

Tillage methods affect the amount of residue on the soil surface from the previous crop. Greater residue coverage helps reduce moisture runoff and erosion. Conventional tillage methods were used on nearly all of the 1989 cotton and rice acreage, and 75-85 percent of the corn, soybean, and winter wheat acreage. Use of no-till systems varied from less than 1 percent in cotton and rice to 10 percent in southern soybean production. Conventional tillage systems with the moldboard plow left 2 percent or less of the soil surface covered with residue after planting, while those without the moldboard plow left 3-17 percent. Mulch-tillage systems left nearly 40 percent, and no-till systems averaged 65-70 percent.

Land containing highly erosive soils made up 18 percent of the corn, 22 percent of the winter wheat, and 25 percent of the cotton acreage in the major producing States. The moldboard plow was used on 16 percent of the corn, 28 percent of the cotton, and 10 percent of the winter wheat land with highly erosive soils.

In the 1989 crop year, seed use for the eight major crops rose 10 percent to 6.5 million tons from the previous year due to greater planted acreage. Higher seed prices raised the average seed cost per acre for most of the major field crops in 1989. Most field seed prices were boosted significantly by heightened demand, drought-reduced supplies, and increased costs of off-season production. For example, soybean and hybrid corn seed prices rose 24 and 11 percent, respectively.

Seed use for the 1990 crop year is projected to climb only 3 percent from the previous year because of the modest increase in planted acreage. The prices paid index for seeds rose 10 percent in 1989, and will likely remain near year-earlier levels in 1990.

The U.S. trade surplus in seeds for planting surged 29 percent to $211 million in the first 9 months of 1989 over the same period a year earlier. This increase primarily reflects gains in soybean, grain sorghum, flower, and forage seed exports. These gains were partly offset by respective declines of 18 and 16 percent in corn and vegetable seed trade.

Energy prices for farmers will likely remain at or perhaps slightly above 1989 levels due to the anticipated steady price of imported crude oil. Energy expenditures by farmers are predicted to climb 4.6 percent to $9.09 billion in 1990. The increase can be attributed to gains in planted acreage and a modest rise in irrigation.

Farm machinery sales rose an estimated $570 million in 1989 to $6.6 billion. Reduced agricultural debt and higher

Table 1--Acreage assumptions for 1990 input use forecast

Crop	1989 actual	1990 forecast
	Million planted acres	
Wheat	76.6	77.0 - 79.0
Feed grains:	106.2	104.0 - 110.0
Corn	72.3	73.0 - 76.0
Other 1/	33.9	31.0 - 34.0
Soybeans	60.7	57.0 - 60.0
Cotton (all kinds)	10.6	11.7 - 12.7
Rice	2.7	2.7 - 3.1

1/ Sorghum, barley, and oats.

farmland values helped strengthen sales in 1989. Sales of four-wheel-drive tractors surged 52 percent in 1989 and are forecast to rise another 45 percent in 1990. The trend toward fewer, larger farms may have contributed to the gain.

Fertilizer

Demand

U.S. plant nutrient use is forecast to equal 20.6 million nutrient tons during fertilizer year 1989/90 (July 1-June 30), up 5 percent from the 19.6 million tons used in 1988/89. Use is forecast at 11.2 million tons for nitrogen, 4.3 million for phosphate, and 5.1 million for potash. During 1988/89, farmers used 10.6 million tons of nitrogen, 4.1 million of phosphate, and 4.8 million of potash. The projected expansion in acres planted of the major fertilizer using crops and higher application rates for corn, soybeans, and wheat are expected to boost fertilizer use in 1989/90.

Planted area of corn and wheat, the major fertilizer using crops, is expected to increase by 1 to 5 percent (table 1). Gains in planted area are also expected for cotton and rice, while decreases of up to 6 percent are anticipated for soybeans.

Fertilizer application rates on corn, soybeans, and wheat are expected to rebound somewhat from their 1989 levels. During that year, application rates on these crops fell because plant nutrients (especially phosphate and potash) were likely carried over in the soil from the drought-stunted 1988 crop, and wet soil conditions prevented spring fertilizer applications in some areas. Spring 1990 fertilizer prices will likely be lower than a year earlier since anticipated 1989 fertilizer use did not fully materialize, leaving excess supplies; prices for most crops will be supported by tightening supplies in relation to use.

Exports of nitrogen fertilizer materials during 1989/90 are projected to rise from a year earlier due to more competitive prices resulting from the large inventory buildup of last spring and summer and the lower value of the dollar compared with other currencies. Overall, nitrogen exports will likely climb 4 percent. Phosphate exports may expand 5 percent if diammonium phosphate shipments to Asia stay strong. Potash exports should remain about the same as last year.

Supplies

Domestic supplies of nitrogen fertilizer should be adequate to meet 1990 crop needs because greater imports will more than make up for reductions in domestic production. The high level of imports and increased domestic production during the first part of 1989 created large inventories, thus weakening market conditions. The market has remained fundamentally weak, as demonstrated by recent plant closures. However, higher domestic demand should reduce inventories, tighten supplies, and strengthen the market during the 1990 crop year. Even with a slight reduction in domestic phosphate production, increased imports and high inventories should ensure sufficient supplies. Domestic potash supplies will also be ample because of increased domestic production supplemented by imports from Canada.

Transportation difficulties may cause some regional shortages of fertilizer materials. The Mississippi River has reached its lowest level in many years. During December 1989, the channel depth at St. Louis was down to about 9 feet. During the peak shipment time (February-March), the river could fall to a traffic-stopping depth of 6 feet. Around the-clock dredging operations are currently being carried out, and barges may have to carry lighter loads. In addition, many other U.S. waterways are frozen during the peak shipment period, forcing shippers to use other shipment means. The U.S. rail system is still plagued by hopper car shortages during peak demand periods, which could trigger spot fertilizer shortages in some areas or higher prices when additional transportation costs are passed on to farmers.

U.S. production capacity for nitrogen decreased during 1988/89 as weak market conditions stopped production in less efficient plants. Production rates for July-October 1989 indicate that 97 percent of U.S. anhydrous ammonia capacity was being used. Wet-process phosphoric acid facilities, capable of producing almost 12.1 million tons of product a year, operated at 96 percent of capacity through October. Anhydrous ammonia and wet-process phosphoric plants operated at about 97 percent of capacity during the same period in 1988.

U.S. potash facilities operated at 88 percent of capacity, producing 2.1 million tons through October 1989; Canadian facilities operated at 51 percent, producing 12.5 million tons. A year earlier, potash plants in both the United States and Canada operated at 73 and 66 percent of capacity, respectively.

Table 2--U.S. supply-demand balance for years ending June 30

Item	Nitrogen			Phosphate			Potash		
	1988	1989	1990 1/	1988	1989	1990 1/	1988	1989	1990 1/
	Million nutrient tons								
Producers' beginning inventory	1.36	1.35	1.51	0.51	0.55	0.70	0.22	0.16	0.22
Production	13.43	14.02	13.94	3/ 11.24	3/ 11.72	3/ 11.70	1.52	1.63	1.70
Imports	2/ 1.36	2/ 1.61	2/ 1.66	0.16	0.07	0.08	4.74	4.07	3.93
Total available supply	4/ 16.15	4/ 16.99	4/ 17.12	11.90	12.34	12.47	6.48	5.86	5.85
Agricultural consumption	10.51	10.63	11.19	4.13	4.12	4.31	4.97	4.83	5.14
Exports	3.03	2.92	3.04	5/ 4.11	5/ 4.80	5.06	0.54	0.40	0.40
Total agricultural and export demand	13.54	13.56	14.23	5/ 8.24	5/ 8.93	9.37	5.51	5.23	5.53
Producers' ending inventory	1.35	1.51	1.40	0.55	0.70	0.60	0.16	0.22	0.20
Available for non-agricultural use	4/ 1.26	4/ 1.93	4/ 1.48	3.10	2.71	2.50	0.80	0.41	0.12

1/ Forecast. 2/ Does not include anhydrous ammonia; effective January 1989, reporting of quantity data for anhydrous ammonia was discontinued by the U.S. Department of Commerce. Anhydrous ammonia typically accounts for 50-70 percent of total nitrogen imports; consequently, nitrogen imports are significantly understated. 3/ Does not include phosphate rock. 4/ Significantly understated due to the lack of import data for anhydrous ammonia. 5/ Due to a data reporting change by the U.S. Department of Commerce, exports of superphosphoric acid are not included prior to January 1989. Thus, phosphate exports and total agricultrual and export demand are understated.

Sources: (2, 3, 6, 7, 8).

U.S. nitrogen production is projected to decrease less than 1 percent in 1989/90 from the previous year (table 2). However, wholesale anhydrous ammonia prices have risen since December as supply and demand conditions have tightened.

Nitrogen imports will increase about 3 percent to meet the projected increase in domestic demand. Increased shipments will likely come from the USSR and Trinidad-Tobago. Canada will continue to be the major U.S. supplier of nitrogen, although shipments are unlikely to show a significant gain over 1988/89 (1). During 1988/89, anhydrous ammonia production rose 4 percent to 17.1 million tons (table 3). Increased production of other nitrogen materials ranged from 6 percent for urea to 20 percent for ammonium nitrate.

Table 3--U.S. production of selected fertilizer materials for years ending June 30

Material	1988	1989 1/	Annual change
	1,000 tons		Percent
Nitrogenous fertilizers: 2/			
Anhydrous ammonia 3/	16,384	17,103	4
Ammonium nitrate, solid	1,909	2,295	20
Ammonium sulfate	2,239	2,393	7
Urea 3/	7,578	8,053	6
Nitrogen solutions	2,545	3,019	19
Phosphate fertilizers: 4/			
Normal and enriched superphosphate	75	73	-3
Triple superphosphate	925	931	1
Diammonium phosphate	5,376	6,185	15
Other ammonium phosphates and other phosphatic fertilizer materials	1,119	1,204	8
Total 5/	7,495	8,393	12
Wet-process phosphoric acid 6/	10,620	11,105	5
Muriate of potash: 7/			
United States	1,520	1,628	7
Canada	8,642	8,916	3

1/ Preliminary. 2/ Total not listed because nitrogen solutions are in 1,000 tons of N, while other nitrogen products are in 1,000 tons of material. 3/ Includes material for nonfertilizer use. 4/ Reported in 1,000 tons P205. 5/ Totals may not add due to rounding. 6/ Includes merchant acid. 7/ Reported in 1,000 tons of K20.

Sources: (2, 8).

U.S. phosphate production is expected to decrease a little in 1989/90 in response to higher inventories. However, steady domestic demand and continued strength in the export market are anticipated. Total production of selected phosphate fertilizer materials in 1988/89 increased 12 percent from a year earlier. Diammonium phosphate production, which accounts for the largest proportion of total U.S. phosphate fertilizer production, rose 15 percent. Production of normal and enriched superphosphates dropped 3 percent. Triple superphosphate production increased about 1 percent.

In 1989/90 potash production will likely increase by about 4 percent as greater domestic demand stimulates production. U.S. potash imports are expected to decline by about 3 percent as U.S. suppliers obtain some of Canada's market share.

Farm Prices

Spring 1990 fertilizer prices are expected to rise 4 percent from October 1989, exhibiting the typical seasonal increase. However, prices will not reach their year-earlier level because supplies (a large inventory carryover from last year plus imports and production) of all nutrients appear to be adequate. Overall, spring 1990 prices are forecast to average 4 percent below those of spring 1989. Nitrogen prices will likely increase the most since last fall as domestic supplies tighten. Phosphate prices will also rise over the fall as the export market demonstrates continued strength. Potash prices, however, could fall to $150 per ton if the price cuts initiated by Canadian producers in December continue.

After rising steadily from October 1986 to April 1989, average fertilizer prices paid by farmers fell 7 percent by October 1989 (table 4). Nitrogen prices fell the most, with anhydrous ammonia and urea prices down about 20 percent from April. Phosphate prices also fell considerably from April to October 1989; triple superphosphate and diammonium phosphate prices fell 11 and 15 percent, respectively. Potash price declines were limited by the January 1988 agreement between the U.S. Department of Commerce (DOC) and Canadian potash producers which restricts Canadian producers from dumping potash in the United States.

The proposed reclassification of anhydrous ammonia as a poisonous rather than a nonflammable gas, formally announced by the U.S. Department of Transportation (DOT) in May 1987, is still under review. DOT, honoring a request from the Railway Labor Executives' Association and the Environmental Policy Institute/ Friends of the Earth, has again reopened the case for comments on the reclassification. In July 1989, DOT's Research and Special Programs Administration decided not to reclassify anhydrous ammonia as a poisonous gas, and opened up its ruling to comment. The ruling stated that although anhydrous ammonia would retain its current NONFLAMMABLE GAS designation, it would have to be identified as an INHALATION HAZARD on the tanks and shipping papers. DOT reported in the Federal Register that the comment period (the sixth in 2 years) had been extended so that legitimate and widespread comments could be received from another sector of the affected public.

U.S. Fertilizer Trade

On January 1, 1989, the DOC ceased reporting quantity data for anhydrous ammonia imports. The DOC took this action in response to a disclosure petition filed by a fertilizer importer. Typically, anhydrous ammonia imports account for 35-60 percent of total nitrogen material imports and 15-25 percent of total fertilizer material imports. Thus, the quantity of U.S. fertilizer trade data will be understated in this report.

Table 4--Average U.S. farm prices for selected fertilizer materials 1/

Year	Anhydrous ammonia (82%)	Urea (44-46%)	Triple superphosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed fertilizer (6-24-24%)	Prices paid index (1977=100)
				$/ton			
1985:							
May	252	217	203	240	128	192	135
October	237	204	195	229	113	182	130
1986:							
April	225	174	190	224	111	179	125
October	174	159	182	205	107	173	116
1987:							
April	187	161	194	220	115	176	117
October	180	159	206	231	135	183	121
1988:							
April	208	183	222	251	157	208	132
October	191	188	221	246	157	208	134
1989:							
April	224	212	229	256	163	217	141
October	180	172	204	218	153	196	131

1/ Based on a survey of fertilizer dealers conducted by the National Agricultural Statistics Service, USDA.

Table 5--U.S. imports of selected fertilizer materials

Material	Fertilizer year 1987/88	Fertilizer year 1988/89	July - October 1988	July - October 1989
	1,000 tons			
Nitrogen:				
Anhydrous ammonia	3,200	1/	1,192	1/
Aqua ammonia	na	na	na	26
Urea	2,155	2,241	465	550
Ammonium nitrate	238	414	69	114
Ammonium sulfate	290	357	88	100
Sodium nitrate	122	156	44	22
Calcium nitrate	169	120	50	28
Nitrogen solutions	595	632	146	94
Other	68	82	32	10
Phosphate:				
Ammonium phosphates	125	69	33	4
Crude phosphates	544	1,073	351	154
Phosphoric acid 2/	1	2	*	1
Normal and triple superphosphate	146	*	*	1
Other	1	2	*	2
Total	816	1,145	384	162
Potash:				
Potassium chloride	7,672	6,567	2,006	1,779
Potassium sulfate	83	90	21	10
Potassium nitrate 3/	74	91	27	11
Total	7,829	6,748	2,054	1,800
Mixed fertilizers	111	145	12	90
Total 4/	12,393	12,041	3,344	2,996
	$ billion			
Total value 5/	1.24	1.39	0.36	0.32

na = Not available. * = Less than 500 tons.

1/ Effective January 1989, reporting of quantity data for anyhdrous ammonia was discontinued by the U.S. Department of Commerce. 2/ Includes all forms of phosphoric acid. 3/ Includes potassium sodium nitrate. 4/ Totals do not include anhydrous ammonia. 5/ Value by fertilizer material in appendix table 1.

Source: (7).

Table 6--U.S. exports of selected fertilizer materials 1/

Material	Fertilizer year 1987/88	Fertilizer year 1988/89	July - October 1988	July - October 1989
	1,000 tons			
Nitrogen:				
Anhydrous ammonia	953	612	277	165
Aqua ammonia	3	14	0	10
Urea	1,133	1,025	510	608
Ammonium nitrate	120	65	28	71
Ammonium sulfate	943	842	339	331
Sodium nitrate	8	2	1	1
Nitrogen solutions	806	680	396	148
Other	86	61	18	16
Total	4,052	3,301	1,569	1,350
Processed phosphate:				
Normal superphosphate	12	22	14	9
Triple superphosphate	1,194	740	405	229
Diammonium phosphate	6,414	7,941	2,737	3,865
Monoammonium and other ammonium phosphates	716	862	326	364
Phosphoric acid--				
Wet-process	448	584	141	348
Super	na	na	na	23
Other	na	na	na	96
Total	8,784	10,149	3,623	4,934
Phosphate rock 2/	9,980	10,020	3,376	2,905
Potash:				
Potassium chloride	528	477	157	192
Potassium sulfate	324	192	66	30
Other	240	284	80	128
Total	1,092	953	303	350
Mixed fertilizers	29	172	7	130
Total	23,937	24,595	8,878	9,669

na = Not available.

1/ Declared value of exports not reported after 1985. 2/ Effective January 1984, phosphate rock exports include a small tonnage of miscellaneous fertilizers.

Source: (6).

Fertilizer import volume in 1988/89, excluding anhydrous ammonia imports, decreased about 3 percent from a year earlier, while value increased around 12 percent (table 5). Imports totaled approximately 12.0 million tons (5.8 million nutrient tons), valued at $1.1 billion. With the value of anhydrous ammonia imports included, value of 1988/89 imports reached $1.4 billion. Canada provided a substantial share of U.S. nitrogen imports and almost all potash imports.

Fertilizer exports totaled 24.6 million tons (8.1 million nutrient tons), up about 3 percent from 1987/88 (table 6). Asian countries provided the largest markets, followed by Canada and Latin America. China received about 10 percent of all U.S. fertilizer exports; South Korea, Canada, Japan, and the Netherlands received over 13, 12, 11, and 11 percent, respectively, of phosphate rock exports.

Fertilizer import volume, excluding anhydrous ammonia, decreased about 10 percent during the first 4 months (July-October) of fertilizer year 1989/90 (table 5). Exports increased 9 percent from a year earlier (table 6). Imports of potassium chloride, the major source of potash, dropped 11 percent. Processed phosphate exports rose 41 percent, while phosphate rock exports fell 14 percent.

Nitrogen

Expectations of increased U.S. planted crop acreage in 1989 encouraged nitrogen imports and, to some degree, discouraged exports. Nitrogen imports in 1988/89 (material basis) rose 27 percent, while exports decreased 14 percent.

Imports of all nitrogen materials increased in 1988/89. Urea and nitrogen solutions imports climbed 4 and 6 percent; ammonium nitrate and sodium nitrate imports surged 74 and 29 percent, respectively. Urea imports reached 2.2 million tons. During the previous fertilizer year, anhydrous ammonia represented 48 percent of all nitrogen material imports, followed by urea (32 percent), nitrogen solutions (9 percent), and ammonium nitrate and ammonium sulfate (4 percent each). Based on information for 1988/89 (excluding anhydrous ammonia), urea represented 47 percent of nitrogen material imports, followed by aqua ammonia and nitrogen solutions, at 14 percent each.

In 1988/89 Canada remained the most important foreign supplier of nitrogen fertilizer, providing about 37 percent of U.S. import tonnage. On a value basis, Canada was the major source of U.S. anhydrous ammonia imports, receiving over 42 percent of anhydrous ammonia import value. Canada also provided most of the imported urea, supplying about 49 percent of the 2.2 million tons of U.S. imports. Trinidad-Tobago and the Netherlands shipped another 5 and 7 percent, respectively.

In 1988/89 the volume of all nitrogen material exports decreased from the previous year. Overall nitrogen exports fell 14 percent. Urea and nitrogen solutions exports decreased 10 and 16 percent, respectively (table 6). Urea exports made up 31 percent of the 3.3 million tons of nitrogen materials exported; ammonium sulfate, 26 percent; nitrogen solutions, 21 percent; anhydrous ammonia, 19 percent; and ammonium nitrate, 2 percent. Diammonium phosphate (18 percent nitrogen and 46 percent phosphate) accounted for over 49 percent of the 2.9 million nutrient tons of nitrogen exported.

Brazil was the largest customer for U.S. ammonium sulfate, purchasing 57 percent of the 0.8 million tons exported. China, Chile, and Canada purchased the most urea, representing 39, 15, and 8 percent, respectively. France was the largest purchaser of nitrogen solutions, taking 52 percent.

Phosphate

At 10.1 million tons, U.S. phosphate fertilizer exports in 1988/89 jumped 16 percent from the previous year. Exports of all phosphate fertilizer materials increased--except for triple superphosphate, which fell 38 percent. Exports of phosphoric acid, diammonium phosphates, and monoammonium phosphates went up 30, 24, and 20 percent, respectively. Forty-three percent of all phosphoric acid exports went to India. Bangladesh received about 34 percent (253,000 tons) of concentrated superphosphate exports. China received 27 percent (2.1 million tons) of diammonium phosphate exports, and Canada received 34 percent (291,000 tons) of monoammonium phosphate exports. South Korea purchased the most U.S. phosphate rock, accounting for 13 percent of all exports, while Canada and Japan took 12 and 11 percent, respectively.

China was the largest purchaser of U.S. phosphate fertilizer in 1988/89, accounting for 21 percent of phosphate exports. Other important customers were India, which took 17 percent; Canada, 10 percent; and Japan, 9 percent. Although data on exports of superphosphoric acid to the USSR are not available, the Soviets buy large amounts of U.S. phosphate fertilizer.

At 10.0 million tons, U.S. phosphate rock exports remained steady in 1988/89, continuing a trend toward shipping processed phosphate fertilizer rather than rock. The phosphate rock of other exporting countries has a higher ore content than that of the United States.

Potash

U.S. potassium chloride imports decreased about 4 percent in 1988/89 to 6.6 million tons (table 5). Potassium chloride accounted for almost all potash imports, with Canada providing 89 percent of the total, up from 88 percent the previous year. Israel and the USSR were the only other significant suppliers, with 5 and 4 percent, respectively.

U.S. exports of potassium fertilizer materials fell about 13 percent in 1988/89. Approximately 1.0 million tons were shipped, with potassium chloride accounting for 50 percent of the total (table 6). Potassium sulfate exports plunged 41 percent, comprising 20 percent of total potassium exports.

Fertilizer Use Estimates

In 1988/89, 44.9 million tons of fertilizer material were used in the United States and Puerto Rico, up 1 percent from the previous year (table 7). However, total use of plant nutrients remained the same at 19.6 million tons. Nitrogen use increased 1.2 percent to 10.6 million tons, but phosphate and potash use slipped 0.1 and 2.8 percent to 4.1 and 4.8 million tons, respectively.

Changes in regional consumption were mixed. Plant nutrient use fell as much as 3 percent in the Lake States and rose as much as 9 percent in the Mountain region, due to changes in planted acreage and phosphate and potash carryover from the 1988 drought conditions (table 8). Nitrogen use increased in all regions except the Lake States, Northern Plains, and Pacific regions, where it dropped from 1 to 4 percent (table 9). Use of phosphate decreased in the Northeast, Lake States, Corn Belt, Appalachia, and Pacific regions, but rose in all others. Potash use declined in all regions except the Southeast, Southern Plains, Mountain, and Northern Plains.

The proportion of fertilizers applied as single nutrient materials retained its market share, constituting 59 percent of U.S. fertilizer use in 1988/89 (table 10). Farmers continued their shift toward the use of more concentrated materials to meet plant nutrient needs.

Nutrient carryover from the drought of 1988 and the wet spring of 1989 reduced application rates on the corn, soybean, and wheat crops in 1989 (table 11). Cotton alone showed an increase.

Table 7--U.S. fertilizer consumption 1/

Year ending June 30 2/	Total fertilizer materials	Primary nutrient use: N	P205	K20	Total 3/	Share of total (1977=100)
	Million tons					Percent
1977	51.6	10.6	5.6	5.8	22.1	100
1980	52.8	11.4	5.4	6.2	23.1	104
1981	54.0	11.9	5.4	6.3	23.7	107
1982	48.7	11.0	4.8	5.6	21.4	97
1983	41.8	9.1	4.1	4.8	18.1	82
1984	50.1	11.1	4.9	5.8	21.8	99
1985	49.1	11.5	4.7	5.6	21.7	98
1986	44.1	10.4	4.2	5.1	19.7	89
1987	43.0	10.2	4.0	4.8	19.1	86
1988	44.5	10.5	4.1	5.0	19.6	89
1989	44.9	10.6	4.1	4.8	19.6	89

1/ Includes Puerto Rico. Detailed State data shown in appendix table 2. 2/ Fertilizer use estimates for 1977-84 are based on USDA data; those for 1985-1989 are TVA estimates. 3/ Totals may not add due to rounding.

Source: (3).

Table 8--Regional plant nutrient consumption for year ending June 30 1/

Region	1988	1989	Annual change
	1,000 tons		Percent
Northeast	720	733	2
Lake States	2,410	2,340	-3
Corn Belt	6,419	6,269	-2
Northern Plains	2,344	2,331	-1
Appalachia	1,468	1,479	1
Southeast	1,425	1,498	5
Delta States	893	927	4
Southern Plains	1,669	1,708	2
Mountain	857	933	9
Pacific 2/	1,377	1,341	-3
U.S. total 3/	19,582	19,558	-0.1

1/ Includes N, P205, and K20. Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 2.

Source: (3).

Table 9--Regional plant nutrient use for year ending June 30 1/

Region	1988	1989	Annual change
	1,000 tons		Percent
Nitrogen:			
Northeast	278	313	13
Lake States	1,053	1,011	-4
Corn Belt	2,991	3,041	2
Northern Plains	1,737	1,680	-3
Appalachia	592	613	3
Southeast	614	643	5
Delta States	523	560	7
Southern Plains	1,204	1,217	1
Mountain	583	626	7
Pacific 2/	924	916	-1
U.S. total 3/	10,498	10,619	1.2
Phosphate:			
Northeast	193	188	-2
Lake States	505	477	-5
Corn Belt	1,303	1,254	-4
Northern Plains	486	522	7
Appalachia	370	361	-3
Southeast	280	297	6
Delta States	153	154	1
Southern Plains	324	342	5
Mountain	228	253	11
Pacific 2/	281	270	-4
U.S. total 3/	4,123	4,119	-0.1
Potash:			
Northeast	249	232	-7
Lake States	852	852	-0
Corn Belt	2,126	1,974	-7
Northern Plains	121	129	7
Appalachia	506	506	-0
Southeast	531	558	5
Delta States	217	212	-2
Southern Plains	140	149	6
Mountain	46	53	15
Pacific 2/	171	155	-9
U.S. total 3/	4,960	4,820	-2.8

1/ Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 3.

Source: (3).

Table 10--Average annual U.S. fertilizer use 1/

Year ending June 30 4/	Multiple nutrient 2/ Quantity	Multiple nutrient 2/ Share of total	Single nutrient 3/ Quantity	Single nutrient 3/ Share of total
	Million tons	Percent	Million tons	Percent
1980	23.3	44	29.5	56
1981	23.5	44	30.5	56
1982	20.9	43	27.8	57
1983	18.4	44	23.5	56
1984	21.2	42	28.9	58
1985	20.6	44	26.7	56
1986	17.8	42	24.7	58
1987	17.1	42	24.1	58
1988	17.6	41	25.1	59
1989	17.5	41	25.3	59

1/ Includes Puerto Rico. 2/ Fertilizer materials that contain more than one primary nutrient. 3/ Materials that contain only one nutrient. 4/ Fertilizer use estimates for 1980-84 are based on USDA data; those for 1985-89 are TVA estimates.

Source: (3).

Table 11--Fertilizer use on selected U.S. field crops 1/

Crop, year	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20
	Percent				Lb./ acre		
Corn for grain:							
1985	98	97	86	79	140	60	84
1986	96	95	84	76	132	61	80
1987	96	96	83	75	132	61	85
1988	97	97	87	78	137	63	85
1989	97	97	84	75	131	59	81
Cotton:							
1985	76	76	50	34	80	46	52
1986	80	80	50	39	77	44	50
1987	76	76	47	33	82	44	45
1988	80	80	54	32	78	42	39
1989	79	79	54	32	84	43	40
Rice:							
1988	99	99	46	36	127	47	50
1989	99	99	46	33	125	45	45
Soybeans:							
1985	32	17	28	30	15	43	72
1986	33	18	29	31	15	43	71
1987	30	15	25	28	20	47	75
1988	32	16	26	31	22	48	79
1989	34	17	28	32	18	46	74
Northern area	30	14	23	28	16	48	77
Southern area	44	24	42	44	21	43	67
All wheat:							
1985	77	77	48	16	60	35	36
1986	79	79	48	19	60	36	44
1987	80	80	50	15	62	35	43
1988	83	83	53	18	64	37	52
1989	81	81	53	18	62	37	46

1/ Detailed data for selected States by crop shown in appendix tables 3-7.

Corn for Grain

Fertilizer was applied to 97 percent of the corn acres in 1988/89. The proportion of acres fertilized with nitrogen remained unchanged, but the proportion of acres fertilized with phosphate and potash declined. Application rates of nitrogen, phosphate, and potash declined from a year earlier to 131, 59, and 81 pounds per acre, respectively.

Cotton

About 79 percent of cotton acreage received some fertilizer in 1988/89, down 1 percent from a year earlier, as the proportion of acres fertilized with nitrogen decreased and the proportion of acres fertilized with phosphate and potash remained the same as last year. However, application rates for nitrogen, phosphate, and potash increased to 84, 43, and 40 pounds per acre, respectively.

Rice

Fertilizer was applied on 99 percent of the rice acreage in 1988/89; the proportion of acres treated with each nutrient ranged from 99 percent for nitrogen to 33 percent for potash. The application rate for nitrogen dropped from a year earlier to 125 pounds per acre; rates for phosphate and potash declined to 45 pounds each from last year.

Soybeans

Some fertilizer was applied to 34 percent of soybean acres planted in 1988/89, up 2 percent from last year as the proportion of acres fertilized rose for all three nutrients. However, application rates for all three decreased from the preceding year. Application rates were highest for potash at 74 pounds per acre, followed by phosphate at 46 pounds and nitrogen at 18 pounds. Some differences in application rates between the northern and southern areas existed, with the Northern area applying less nitrogen per acre but more phosphate and potash.

Wheat

The share of wheat acres fertilized decreased to 81 percent; the proportion of acres treated with nitrogen fell to 81 percent, while the proportion treated with phosphate and potash held steady at 53 and 18 percent, respectively. Nitrogen and potash application rates decreased to 62 and 46 pounds per acre, respectively; the rate for phosphate remained the same as last year--37 pounds.

World Fertilizer Review and Prospects

World plant nutrient production and use increased in 1987/88 and is projected to have also expanded in 1988/89. Fertilizer production and consumption rose significantly in developing market economies, but only slightly in developed market economies.

Table 12--World plant nutrient supply and consumption for years ending June 30

Plant nutrient	1987	1988	1989 1/	Percent change 1986/87 to 1987/88	Percent change 1987/88 to 1988/89
	Million metric tons				
Available supply: 2/					
Nitrogen	72.6	77.1	79.9	6.20	3.63
Phosphate	34.9	37.1	40.6	6.30	9.48
Potash	26.1	27.7	30.8	6.13	11.12
Total 3/	33.6	141.9	151.3	6.21	6.62
Consumption:					
Nitrogen	71.7	76.0	78.5	6.00	3.26
Phosphate	34.7	36.9	38.1	6.34	3.14
Potash	26.2	27.5	27.7	4.96	0.69
Total 3/	132.6	140.5	144.2	5.96	2.65

1/ Projected. 2/ Production less industrial uses and losses in transportation, storage, and handling. 3/ Totals may not add due to rounding.

Source: (4, 5).

Supplies

In 1987/88, world plant nutrient supplies increased over 6 percent to 141.9 million metric tons (table 12). Nitrogen supplies expanded over 6 percent to 77.1 million tons; phosphate supplies went up by 6 percent to 37.1 million metric tons. Potash supplies reached 27.7 million metric tons (up about 6 percent). Greater production probably boosted world plant nutrient supplies about 7 percent last year.

U.S. planted acreage will likely increase in 1990 because changes in Government programs for wheat and feed grains could reduce acreage being taken out of production. In addition, planted acreage outside the United States is expected to expand, encouraging greater fertilizer production and consumption.

Consumption

World plant nutrient consumption in 1987/88 increased about 6 percent from a year earlier to about 140.5 million metric tons (table 12). Nitrogen and phosphate use climbed about 6 percent each, while potash use rose 5 percent. Nitrogen, phosphate, and potash consumption increased to about 76, 36.9, and 27.5 million metric tons, respectively. World plant nutrient use rose an estimated 2.7 percent in 1988/89 due to increased demand in the developing market economies of Latin America and Asia.

Projections for 1989-94

According to the 1989 forecasts of the Food and Agricultural Organization/World Bank, world nitrogen, phosphate, and potash fertilizer consumption is expected to grow 12, 12, and 9 percent, respectively, during 1989-94 (table 13). Fertilizer production and use are projected to grow fastest in developing countries and the centrally planned economies of Asia.

In developed countries, consumption is expected to expand less than 3 percent by 1994, down from earlier projections of over 10-percent growth. The reduction in the rate of growth in U.S. consumption forecasts is due to the assumed continuation of acreage set-aside programs. Stable demand in Western Europe will also slow growth in world fertilizer use and curb nitrogen and phosphate production rates. North American potash exports are expected to rise, supporting growth in U.S. and Canadian potash production. Smaller production increases in Eastern Europe and the USSR could reduce those countries' exports.

Recent deterioration in the world fertilizer market has brought about a response from producers in the higher cost producing regions of the world. For example, in Western Europe and North America, facilities able to produce over 2 million tons of ammonia capacity have been closed. The companies cite strong competitive pressures and low prices as reasons for halting production. Some of these plants will be mothballed and sold. Nitrogen demand growth in both

Table 13--Projected 1989-94 change in world fertilizer supply and consumption 1/

World regions	Nitrogen	Phosphate	Potash
	Percent increase		
Supply potential:			
Developed market economies	0	1	1
Developing market economies	25	13	34
Eastern Europe and the USSR	5	10	5
Centrally planned countries of Asia	13	14	142
Total	10	7	4
Consumption:			
Developed market economies	0	2	3
Developing market economies	25	23	21
Eastern Europe and the USSR	12	11	5
Centrally planned countries of Asia	11	20	34
Total	12	12	9

1/ Detailed data in appendix table 8.

Source: (4).

Western Europe and the United States is uncertain. It is not clear whether these plant closures will help lift prices in the near future, since there is ample supply from outside these regions to cover current demand.

Nitrogen production in the developed countries is expected to be constant, while both phosphate and potash production will likely grow 1 percent. Most of the increase will come from greater Canadian potash production. Israel is also expected to expand potash production. Higher phosphate fertilizer production in the United States will depend heavily on phosphate export potential.

In the developing countries, the supply potential for the three plant nutrients will climb from 13 to 34 percent by 1994, while consumption will be up by 21 to 25 percent. The rapid rise in consumption can be attributed to the goal of many developing countries to become self-sufficient in food and fertilizer production.

New and more efficient ammonia plants are scheduled to be completed during the next few years in Trinidad-Tobago, the United Kingdom, and Belgium. New urea plants are scheduled for Iraq, Saudi Arabia, Indonesia, Bangladesh, India, Pakistan, Java, and China. Nitrogen production is expected to increase near natural gas reserves in Indonesia, India, Saudi Arabia, Mexico, and Trinidad-Tobago. Among Asian and Eastern European centrally planned countries, greater nitrogen production capacity will be limited mostly to those plants built in China. France, the Netherlands, and the United Kingdom are expected to expand production.

This surplus of nitrogen production capacity will likely provide sufficient supplies until the year 2000. However, excess production capacity will by then have been reduced; price increases will therefore be needed to make it profitable for producers to expand production to meet demand.

Africa, Asia, Oceania, and Western Europe are projected to be nitrogen-deficient through 1994. Eastern Europe, Latin America, the Near East, and the USSR will have surpluses because countries with plentiful natural gas resources produce nitrogen fertilizer for export.

Phosphate production will center primarily in the United States, the USSR, and Morocco during 1989-94. About 33 percent of the phosphoric acid supply capability will be located in the United States, 20 percent in the USSR, and 10 percent in Morocco. Increased phosphate production in India, China, Mexico, Tunisia, and Brazil will also add to world supplies.

The developed countries and Africa are projected to have surpluses of phosphate fertilizer; the USSR, Asia, and Eastern Europe will be deficit areas, with Asia having the most acute shortage.

Worldwide, phosphate rock capacity will be more than adequate to meet demand, with the main surplus areas being North America and Africa. The USSR and India are forecast to be the world's largest importers of phosphoric acid, accounting for an estimated 45 percent of world trade. China, Jordan, Brazil, Mexico, India, and Morocco will also remain significant importers of processed phosphates through the early 1990's, since the excavation of new phosphate mines in those countries will take a long time and their phosphate rock processing facilities have not been fully developed.

Potash supply capability should be adequate into the next decade. World potash production potential is expected to increase about 4 percent. The greatest surplus is forecast for North America, due to heightened Canadian production. Canada will add the most capacity worldwide, with other additions coming from Israel, Jordan, Brazil, Thailand, and China. The development of potash production capability in Brazil and China has been progressing satisfactorily. Virtually no change in capacity is foreseen in Western Europe. Production problems and mine flooding may impede any significant change in USSR capability through 1994. No significant development is expected for the next few years in Chile, the Congo, Ethiopia, Thailand, or Tunisia.

Eastern Europe and the USSR will have major potash surpluses. Western Europe, Asia, Africa, and Latin America are projected to be deficit areas.

Projected regional shares of world fertilizer supply and demand indicate a continued shift in production and use from the developed to the developing countries. The centrally planned countries' share of world production will remain relatively constant at around 44 percent through 1994. Their consumption will also remain about the same--35 percent (table 14).

World Trade Developments

Existing nitrogen trade patterns should continue. Eastern Europe and the USSR will continue to supply nitrogen fertilizer to the United States, Western Europe, and Asia. Additional nitrogen fertilizer production in Trinidad-Tobago will compete for a share of the already-crowded North American, West European, and Mediterranean markets. Surplus nitrogen from the Near East will probably move to Asian markets.

Phosphate production is expected to grow in most regions. Although U.S. consumption is stabilizing, world consumption will increase, tightening the supply-demand balance. Asia should have the most active trade, since countries in that region are expected to produce only a small share of the phosphate they need. The African and U.S. phosphate industries will compete for this growing market.

Table 14--Projected regional shares of world fertilizer supply potential and demand for years ending June 30

World regions	Nitrogen 1989	Nitrogen 1994	Phosphate 1989	Phosphate 1994	Potash 1989	Potash 1994
			Percent			
Supply potential:						
Developed market economies:	27.5	25.1	45.0	42.5	53.3	52.0
North America	14.1	13.0	24.7	24.3	32.5	31.4
Western Europe	11.6	10.7	13.3	11.5	16.8	16.5
Oceania	0.4	0.4	3.0	2.9	0.0	0.0
Other countries	1.3	1.0	4.1	3.8	3.9	4.1
Developing market economies:	22.7	25.9	23.0	24.3	2.5	3.3
Africa	0.6	0.8	9.9	10.6	0.0	0.0
Latin America	5.1	5.4	4.7	4.7	0.1	0.2
Asia	16.9	19.8	8.4	9.0	2.4	3.0
Eastern Europe and the USSR	31.4	30.1	23.9	24.6	44.1	44.5
Centrally planned countries of Asia	18.4	18.9	8.1	8.6	0.1	0.3
Consumption:						
Developed market economies:	30.5	27.5	31.1	28.2	41.2	39.2
North America	14.4	13.2	12.1	11.1	18.1	17.8
Western Europe	14.1	12.4	13.1	11.5	19.6	18.0
Oceania	0.5	0.6	3.1	3.0	0.9	1.0
Other countries	1.4	1.3	2.8	2.6	2.7	2.5
Developing market economies:	25.5	28.7	25.0	27.4	17.4	19.4
Africa	1.1	1.3	1.8	2.0	1.1	1.3
Latin America	5.3	5.5	7.7	7.7	7.8	8.5
Asia	19.1	21.8	15.5	17.7	8.5	9.5
Eastern Europe and the USSR	21.0	21.1	30.7	30.3	36.3	35.1
Centrally planned countries of Asia	22.9	22.7	13.1	14.1	5.1	6.3

Source: (4).

Canada, East Germany, Israel, and the USSR are the major potash exporters. Canadian exports are expected to outdistance those of other major exporters by further penetrating the large Indian and Chinese markets and continuing shipments to the United States.

World Fertilizer Prices

Intensified use of fertilizer in developing countries has increased world consumption, a trend forecast to continue in the 1990's. World consumption rose by about 2.7 percent in 1988/89, while available supply increased 6.6 percent. This excess supply temporarily dampened world prices. However, heightened demand coupled with lower supply increases will tighten supplies and raise world prices in 1989/90 over fall 1989 prices. The long-awaited resumption of Chinese and Indian demand, as well as strong U.S. import demand, will fuel future upward price trends.

References

1. Agriculture Canada. "Market Commentary: Farm Inputs and Finance." December 1989.

2. Potash/Phosphate Institute. Selected reports. Atlanta, GA.

3. Tennessee Valley Authority, Economics and Marketing Staff. *Commercial Fertilizer Consumption.* December 1989.

4. United Nations, Food and Agricultural Organization. *Current World Fertilizer Situation and Outlook,* 1987/88 to 1993/94. Rome, 1989.

5. __________. *1988 Fertilizer Yearbook.* Rome, 1989.

6. U.S. Department of Commerce, Bureau of the Census. *U.S. Exports, Commodity and Country.* FT-410. October 1989 and earlier issues.

7. __________. *U.S. Imports, Commodity and Country.* FT-135. October 1989 and earlier issues.

8. __________. *Inorganic Fertilizer Materials and Related products.* M28-B. October 1989 and earlier issues.

Pesticides

Demand

Total 1990 farm pesticide use on the major field crops is projected at 470 million pounds, active ingredients (a.i.), up 2 percent from a year earlier (table 15). Planted acreage for all crops will likely rise, except perhaps for soybeans.

Herbicides account for 85 percent of total pesticide use, while insecticides make up 13 percent. The 4.3-million-pound a.i. rise in herbicide use expected in 1990 can largely be attributed to expanded corn acreage, which could exceed

Table 15--Projected pesticide use on major U.S. field crops, 1990

Crops	Herbicides	Insecticides	Fungicides
	Million lbs. (a.i.)		
Row:			
Corn	223.0	27.6	0.06
Cotton	19.4	18.8	0.20
Grain sorghum	11.4	1.9	0.00
Peanuts	6.2	1.3	6.12
Soybeans	103.3	9.0	0.06
Tobacco	1.0	2.4	0.31
Total	364.3	61.0	6.75
Small grains:			
Barley and oats	5.3	0.2	0.00
Rice	12.1	0.5	0.07
Wheat	16.5	2.2	0.91
Total	34.0	2.9	0.98
Total	398.3	63.9	7.73
1989 total	394.0	59.7	7.77

Table 16--U.S. pesticide production, inventories, exports and domestic availability 1/

Item	1989	Projected 1990	Change 89-90
	Million lbs. (a.i.)		Percent
Herbicides:			
Production	553	588	6
Carryover	142	126	-11
Imports 2/	109	109	0
Exports 2/	176	200	14
Domestic availability	628	623	-1
Insecticides:			
Production	236	242	3
Carryover	54	53	-2
Imports 2/	9	15	67
Exports 2/	77	79	3
Domestic availability	222	213	4
Fungicides:			
Production	26	25	-4
Carryover	4	3	-25
Imports 2/	4	6	50
Exports 2/	12	12	0
Domestic availability	22	22	0
All pesticides:			
Production	815	855	5
Carryover	200	182	-9
Imports 2/	122	130	7
Exports 2/	265	291	10
Domestic availability	872	876	0

1/ The responding firms produce a major portion of all U.S. farm pesticides. 2/ Does not include imports or exports by pesticide formulators.

Source: USDA survey of basic pesticide manufacturers, December 1989.

year-earlier levels by 1-5 percent. Corn accounts for 56 percent of total herbicide use.

Insecticide use in 1990 is expected to be up 7 percent from a year earlier, largely on the strength of a 10-20 percent increase in planted cotton acreage. Fungicide use for major field crops is expected to remain stable, with most materials being used in peanut production.

Supplies

Although the domestic supply of pesticides available for U.S. farm use is expected to only equal that of last year, it will still meet 1990 crop needs (table 16). Production is expected to be up 5 percent and inventory carryover down 9 percent. The anticipated 10-percent increase in exports can be attributed in part to the continued low value of the dollar relative to other currencies.

Domestic herbicide supplies for 1990 are projected at 623 million pounds a.i., down 1 percent from last year. Manufacturers are expected to increase production by 6 percent, since in the past year they have drawn down inventories by 11 percent. Herbicide exports are expected to rise 14 percent, while imports will remain stable.

Insecticide supplies are projected to grow by 4 percent in 1990, while fungicide supplies will be the same as a year earlier. Insecticide and fungicide imports are expected to increase 67 percent and 50 percent, respectivelylarge annual percentage changes can occur in these categories because of the small volume handled. A manufacturer may import enough material for two or three crop seasons rather than a single season, as is generally the case with herbicides.

Domestic plant capacity utilization for all pesticides is projected at 84 percent for 1990, up 2 percentage points from 1989 and the highest level in the last 10 years (table 17). Manufacturers are increasing production (especially of herbicides) to meet domestic needs arising from greater planted acreage and continued export expansion.

Prices

Pesticide prices quoted by manufacturers for the 1990 crop season are projected to be up 1-3 percent from last year (table 18). Herbicide prices have increased 3.7-5.5 percent in the last 2 years, while insecticide prices have risen 3 percent a year. Pesticide manufacturing costs have gone up, and the increase in planted acreage has heightened demand.

Table 17--U.S. pesticide production capacity utilization rates

Year	Herbicides	Insecticides	Fungicides	All pesticides
	Percent			
1981	74	72	68	73
1982	84	68	70	80
1983	66	33	71	54
1984	67	29	73	52
1985	62	56	66	61
1986	64	63	61	65
1987	63	61	59	62
1988	75	76	59	75
1989	82	76	63	81
1990 1/	84	83	64	84

1/ Projected.

Source: USDA survey of basic pesticide manufacturers, December 1989.

Table 18--U.S. pesticide price changes

Category	1987-88 1/	1988-89 1/	Projected 1989-90
		Percent	
Herbicides	3.7	5.5	3.2
Insecticides	3.1	2.9	2.7
Fungicides	na	na	1.4

na = Not available.

1/ April prices paid by farmers.

Source: USDA survey of basic pesticide manufacturers, December 1989.

Herbicide Use Over Time

Herbicide active ingredients are not a homogenous lot; each active ingredient controls a specific set of weeds in a population. Based on biological activity, herbicide active ingredients are not perfect substitutes for each other. For example, given a population of 20 weed species, active ingredient 1 may control weed species 1-15, and active ingredient 2 may control 6-20. Thus, if each active ingredient is used alone there are 5 weed species that are not controlled. Therefore, to broaden the spectrum of weed control, farmers frequently mix two or more active ingredients and apply them together.

To select an active ingredient, the farmer must first determine the makeup of the weed population in the field. The next step is to decide which active ingredient will give the greatest weed control at the lowest cost per acre. The crop rotation in a particular field can also affect ingredient selection. Some active ingredients have a residual soil life longer than one cropping season, and some crops are particularly sensitive to certain active ingredients and will be damaged if planted too soon after a herbicide application.

Over time the use of a particular active ingredient may change. Since any one active ingredient will generally not control all weed species in a field, the composition of the weed population will change. The farmer must then switch to another active ingredient to control these new weed problems. Also, some weeds may develop a new strain that can tolerate the currently used active ingredient, again necessitating a change. In addition, when new active ingredients come on the market, farmers will adopt them if they provide better weed control and/or cost less per acre.

To determine if any changes have occurred in herbicide active ingredient use, data from the Cropping Practices Survey conducted by the Economic Research Service and the National Agricultural Statistics Service are reviewed. The survey covers 1986-89 and includes corn, soybeans, cotton, and wheat for the major producing States.

Corn

During the 4 survey years, about 96 percent of the corn acreage was treated with a herbicide (table 19). Examination of the data does not reveal any major shifts in active ingredient use. There does appear to be some decrease in the use of atrazine and an increase in the use of metolachlor; however, more years of data will be needed to see if this trend holds.

Table 19--Selected herbicides used in corn production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	96	96	96	97
1,000 acres treated with herbicides	55370	45761	51301	55972
Percent of treated acres by active ingredient:				
Single materials--				
Alachlor	14	9	10	12
Atrazine	16	12	12	9
Bromoxynil	3	na	3	2
Cyanazine	4	3	3	3
Dicamba	7	5	7	9
EPTC	3	na	6	8
Metolachlor	7	7	7	11
Propachlor	2	na	na	na
2,4-D	7	8	7	8
Other	4	14	4	9
Combination mixes--				
Atrazine + alachlor	20	26	17	15
Atrazine + butylate	4	4	3	4
Atrazine + cyanazine	10	7	9	7
Atrazine + metolachlor	14	14	12	11
Atrazine + others	5	12	9	13
Alachlor + cyanazine	3	3	2	2
Dicamba + 2,4-D	4	4	4	4
Other 2-way mixes	7	7	5	5
3-way mixes	5	7	11	7
Average acre-treatments	1.3	1.2	1.3	1.4

na = Not available separately, but included in the "Other" category.

1/ Detail by State for 1989 in appendix table 9.

Atrazine + alachlor was the most commonly used treatment. Other important treatments include alachlor and atrazine applied as single materials and a combination of atrazine + metolachlor.

Acre-treatments are the treated acres multiplied by the number of applications during the growing season. Farmers may treat the same acre more than once because some weed species escape the original treatment or germinate later in the growing season. Acre-treatments averaged 1.3 during 1986-89, indicating no change in seasonal weed pressure.

Soybeans

Farmers in both the northern and southern regions treat about 96 percent of their soybean acreage with herbicides (tables 20 and 21). However, the weed species and the intensity of weed pressure during the growing season vary between the two regions. Weed pressure is more intense in the southern region, where acre-treatments averaged 1.7 in 1989 compared with 1.5 in the northern region.

Table 20--Selected herbicides used in northern soybean production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	96	95	96	97
1,000 acres treated with herbicides	37540	35797	35654	36782
Percent of treated acres by active ingredient:				
Single materials--				
Alachlor	7	6	4	3
Bentazon	11	13	15	15
Chloramben	5	3	3	3
Chlorimuron-ethyl	2	2	6	4
Ethalfluralin	3	3	3	5
Imazaquin	na	na	3	2
Metolachlor	2	3	3	2
Metribuzin	3	na	3	2
Sethoxydim	2	3	3	2
Trifluralin	22	18	19	25
Other	14	16	10	25
Combination mixes--				
Trifluralin + dimethazone	na	3	3	4
Trifluralin + imazaquin	na	7	6	4
Trifluralin + metribuzin	17	9	8	5
Aciflurofen + bentazon	2	na	4	5
Alachlor + linuron	5	3	4	2
Alachlor + metribuzin	6	4	5	2
Metolachlor + metribuzin	3	3	3	4
Pendimethalin + imazaquin	1	8	7	4
Other 2-way mixes	19	29	20	18
3-way mixes	4	na	6	11
Average acre-treatments	1.3	1.3	1.4	1.5

na = Not available separately, but included in the "Other" categories.

1/ Detail by State for 1989 in appendix table 10.

Table 21--Selected herbicides used in southern soybean production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	96	95	96	93
1,000 acres treated with herbicides	13015	11280	11266	12408
Percent of treated acres by active ingredient:				
Single materials--				
Alachlor	6	4	4	4
Bentazon	5	5	4	6
Chlorimuron-ethyl	6	2	10	10
Fluazifop-butyl	5	5	6	7
Glyphosate	na	5	3	1
Imazaquin	13	14	12	9
Metribuzin	7	5	7	5
Pendimethalin	11	5	7	5
Trifluralin	28	30	29	26
Other	26	25	16	27
Combination mixes--				
Aciflurofen + bentazon	5	12	9	3
Pendimethalin + imazaquin	4	11	7	7
Trifluralin + imazaquin	5	6	8	8
Trifluralin + metribuzin	6	7	5	4
Other 2-way mixes	27	23	24	36
3-way mixes	5	na	9	10
Average acre-treatments	1.6	1.6	1.6	1.7

na = Not available separately, but included in the "Other" categories.

1/ Detail by State for 1989 in appendix table 11.

In the northern soybean region there appears to be a decline in the use of trifluralin + metribuzin and an increase in pendimethalin + imazaquin. Trifluralin, applied preplant incorporated, and bentazon, applied postemergence, are the two most common herbicide treatments.

Before discussing herbicide use in the southern region, it is important to provide some background. Two new active ingredients, imazaquin and chlorimuron-ethyl, were registered in spring 1986 and used extensively. Imazaquin was used on 13 percent of the treated acres and chlorimuron-ethyl on 6 percent in that year. Imazaquin can be applied preplant incorporated, preemergence, or postemergence. It controls many broadleaf and grass weeds and may be tank-mixed with other herbicides to increase the control spectrum. Chlorimuron-ethyl (particularly effective in controlling large cocklebur and sunflower) can only be applied postemergence. Chlorimuron-ethyl can be tank-mixed with acifluorfen to broaden the control spectrum, especially for black nightshade.

Trifluralin is the most commonly used herbicide treatment in the southern soybean region. Chlorimuron-ethyl use has increased in recent years, while pendimethalin use has fallen. Of the combination herbicide mixes used in the region, none dominates.

Cotton

The cotton acreage treated with herbicides ranges from 92 to 95 percent annually (table 22). Herbicide use is more intensive in cotton production than other crops, with acre-treatments averaging about 1.9. The cotton plant grows slowly in the spring, taking a long time to develop a leaf canopy to shade the ground. Without competition from the cotton plant, weeds can germinate easily.

Growers in Arizona, California, and Texas typically make 1-2 herbicide applications during the season, while those in the high-rainfall Delta States normally use 3-4 applications.

Trifluralin is the most commonly used herbicide in cotton production, generally applied as a preplant, soil-incorporated treatment. Fluometuron is used extensively in the Delta, either as a preemergence treatment or a postemergence directed spray. With directed sprays, drop nozzles are used to place the herbicide under the leaf canopy in the crop row. Pendimethalin was used extensively in Texas and the West as a preemergence treatment.

Although no one herbicide combination dominates, MSMA and norflurazon are used in several mixes. MSMA mixes are applied as postemergence directed sprays. If MSMA comes in contact with the foliage, it can damage the cotton plant. Mixes with norflurazon are applied preplant incorporated or preemergence to prevent weed germination.

Table 22--Selected herbicides used in cotton production, 1987-89 1/

Item	1987	1988	1989
Percent of acres treated with herbicides	94	95	92
1,000 acres treated with herbicides	7538	12012	10703
Percent of treated acres by active ingredient:			
Single materials--			
Cyanazine	7	8	8
Fluazifop-butyl	3	5	3
Fluometuron	19	16	18
MSMA	4	3	4
Norflurazon	4	3	5
Pendimethalin	24	21	17
Prometryn	13	11	12
Trifluralin	54	57	63
Other	15	10	10
Combination mixes--			
Cyanazine + MSMA	8	5	4
Fluometuron + MSMA	6	5	4
Fluometuron + norflurazon	6	7	5
Pendimethalin + norflurazon	na	3	2
Prometryn + MSMA	5	5	7
Trifluralin + norflurazon	8	7	8
Other 2-way mixes	18	14	18
3-way mixes	4	2	2
Average acre-treatments	2.0	1.8	1.9

na = Not available separately, but included in the "Other" category.

1/ Detail by State for 1989 in appendix table 12.

Winter Wheat

Winter wheat growers treat 40-50 percent of their acreage annually with herbicides (table 23). In 1987, winterkill was greater than normal, necessitating additional herbicide use to control invading weeds and prevent yield losses. Acre-treatments averaged 1.1 during the 4 survey years. Winter wheat grows rapidly, shading the ground and thus inhibiting weed germination.

The two most common winter wheat herbicide treatments are 2,4-D and chlorsulfuron. Chlorsulfuron was registered in 1982 and 2,4-D patented in 1944. Chlorsulfuron controls a number of broadleaf and grass weeds and can be applied either pre- or postemergence. In contrast, 2,4-D controls only broadleaf weeds and is applied postemergence. Chlorsulfuron quickly became popular, and by 1988 was used on 42 percent of the herbicide-treated winter wheat acreage, while only 21 percent was treated with 2,4-D.

However, in 1988 chlorsulfuron use dropped and 2,4-D use increased, because weeds in some areas exhibited a tolerance to chlorsulfuron. Also, in areas of low annual rainfall, chlorsulfuron remains in the soil for 2-4 years, restricting crop rotation flexibility.

Spring Wheat

Farmers treated 80 to 90 percent of the spring wheat acreage between 1986 and 1989, double that for winter wheat (table 24). The spring preparation of the seedbed provides a good medium for both crop and weed seed germination; consequently, herbicides are needed and used more.

Although 2,4-D is the most commonly used herbicide in spring wheat production, its use has decreased during the past 4 years. Use of MCPA (another phenoxy herbicide) as a single material has also declined. Treatments with combinations of MCPA + bromoxynil and MCPA + dicamba have gone up, enhancing the spectrum of broadleaf weed control.

Table 23--Selected herbicides used in winter wheat production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	42	48	44	39
1,000 acres treated with herbicides	16670	15465	12012	10703
Percent of acres treated by active ingredient:				
Single materials--				
2,4-D	37	35	21	32
Chlorsulfuron	28	27	42	27
Dicamba	3	na	na	3
MCPA	3	2	2	3
Metsulfuron	na	na	na	4
Other	10	11	7	7
Combination mixes--				
2,4-D + chlorsulfuron	3	5	4	3
2,4-D + dicamba	10	10	5	4
2,4-D + glyphosate	na	na	2	3
2,4-D + metsulfuron	na	na	2	4
Other 2-way mixes	12	15	13	14
3-way mixes	3	na	8	7
Average acre-treatments	1.1	1.1	1.1	1.1

na = Not available separately, but included in the "Other" categories.

1/ Detail by State for 1989 in appendix table 13.

Table 24--Selected herbicides used in spring wheat production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	86	89	83	91
1,000 acres treated with herbicides	12490	11493	8097	15046
Percent of treated acres by active ingredient:				
Single materials--				
2,4-D	40	39	33	30
Chlorsulfuron	3	3	4	1
Diclofop-methyl	4	7	5	6
MCPA	18	15	14	11
Triallate	5	3	4	3
Trifluralin	na	5	4	7
Other	17	12	6	15
Combination mixes--				
2,4-D + chlorsulfuron	na	na	3	1
2,4-D + dicamba	10	12	10	12
MCPA + bromoxynil	na	na	9	6
MCPA + dicamba	4	4	6	10
Other	11	17	17	21
Average acre-treatments	1.1	1.2	1.2	1.2

na = Not available separately, but included in the "Other" categories.

1/ Detail by State for 1989 in appendix table 14.

Table 25--Selected herbicides used in durum wheat production, 1986-89 1/

Item	1986	1987	1988	1989
Percent of acres treated with herbicides	98	95	94	96
1,000 acres treated with herbicides	2690	2719	2358	2866
Percent of treated acres by active ingredient:				
Single materials--				
2,4-D	60	50	37	31
Chlorsulfuron	1	5	3	2
Diclofop-methyl	4	5	5	8
MCPA	16	15	15	10
Triallate	5	12	9	3
Trifluralin	na	18	27	30
Other	17	8	15	19
Combination mixes--				
2,4-D + chlorsulfuron	na	na	na	3
2,4-D + dicamba	na	10	10	11
MCPA + bromoxynil	na	na	3	2
MCPA + dicamba	2	3	3	8
Other	17	14	22	22
Average acre-treatments	1.2	1.4	1.5	1.5

na = Not available separately, but included in the "Other" categories.

1/ Detail by State for 1989 in appendix table 14.

Durum Wheat

The herbicide use data here comes from North Dakota, the major durum producing State (table 25). The proportion of acres treated with herbicides ranged from 94 to 98 percent, with an average of 1.5 acre-treatments being applied annually.

Trifluralin and 2,4-D are the herbicides most commonly used on durum wheat. Use of 2,4-D has declined, while that of trifluralin has risen. Nevertheless, these two materials cannot be used interchangeably. Trifluralin controls broadleaf and grass weeds; 2,4-D controls only broadleaf weeds. However, at the low application rates per acre (0.5 pounds a.i. or less) used in North Dakota, trifluralin mainly controls green foxtail (pigeongrass). These rates may afford some pigweed control, but do not kill wild mustard and buckwheat, two other problem weeds. Metsulfuron and DPX-M6316 (appendix table 14) are more effective and have replaced 2,4-D use as a single material in recent years. In addition, use of 2,4-D + metsulfuron (appendix table 14) has increased, broadening the control spectrum over 2,4-D alone.

Regulatory Issues

Current pesticide regulatory concerns are focused on food safety, water quality, and avian mortality. Fungicides used on fruits and vegetables constitute a major food safety concern. In December 1989, the Environmental Protection Agency (EPA) proposed cancelling the registrations of EBDC fungicides (maneb, mancozeb, metiram, and zineb) for use on 45 of 55 fruit and vegetable crops, representing 90 percent of current use.

In September 1989, the leading manufacturers voluntarily suspended EBDC registrations for 42 of the 45 crops. Their use on the three remaining cropstomatoes, potatoes, and bananaswill arouse controversy before EPA makes a final decision. Use of alternative fungicides, including chlorothalonil, could also become a food safety issue. USDA is currently assessing the biological and economic benefits of using fungicides in food production.

In January 1989, EPA proposed cancelling all granular formulations of carbofuran (a soil insecticide and nematicide), because of their contribution to avian mortality. This pesticide is used mainly on corn, sorghum, rice, and peanuts, but it is also important in the production of some fruit and vegetable crops. A study by USDA showed that cancelling granular carbofuran could impede rice production, because there are no known chemical alternatives for controlling rice water weevils. Use of other granular insecticides, including terbufos, phorate, and aldicarb, could also be restricted by EPA. EPA has become concerned about the presence of such pesticides as atrazine and other triazine herbicides in groundwater.

Tillage Systems

Tillage systems and the amount of previous crop residue remaining after planting are important indicators of soil erosion potential. The conservation compliance provisions of the 1985 Food Security Act (FSA) require farmers to protect highly erodible land (HEL) through conservation practices by 1995 to reduce erosion to a specified level, or be ineligible for farm program benefits. The FSA states that a field designated as HEL must have a conservation plan approved by 1990 and that plan must be fully implemented by 1995. To meet these requirements, a change in crop rotation, a change in tillage system, the addition of a cropping practice (such as contouring), and/or the installation of permanent structures may be recommended. In many situations, changing tillage systems may be all that is needed.

The FSA states that if one-third or more of a field consists of highly erosive soils, that field is designated HEL. This leaves highly erosive soils in many fields designated non-HEL. If conservation practices were applied to these non-HEL lands, although not required by the FSA, this would also help improve water quality and protect erosive soils.

The tillage system employed also influences the types and levels of other input use. Labor and fuel inputs are reduced by tillage systems that require fewer trips over the field. On the other hand, a no-till system used on sod or small grain acreage usually necessitates an extra herbicide application to kill the vegetation; in addition, increased fertilizer levels are sometimes recommended.

Of the acreage planted to the major crops, currently 15-30 percent is tilled with a moldboard plow; a no-tillage system is used on 10 percent or less, depending on the crop. Most of the acreage is cropped with conventional tillage without the moldboard plow, a system that leaves less than 30 percent residue on the soil surface after planting. For this report, the percent of residue remaining after planting was assumed to be evenly distributed over the soil surface.

For erosion control purposes, a conservation tillage system is defined as one that leaves 30 percent or more of the soil surface covered with residue after planting. Less than 25 percent of the 1989 crop acreage surveyed meets this criterion, a statistic that may have implications for the amount of land that would currently meet conservation compliance restrictions. Producers farming HEL acres that don't currently meet the 30-percent residue level may have to change their tillage systems or risk losing farm program benefits.

Different tillage systems leave significantly different residue levels. Therefore, the type of tillage system directly affects erosion potential and water quality. In general, conventional tillage systems without the moldboard plow leave less than one-half as much residue after planting as mulch-till systems. Time spent in tilling the soil is related to the number of times the farmer goes over the field, as well as implement size and tractor speed. For example, under conventional tillage without a moldboard plow, the number of passes over the field varies from an average of 3.4 for corn to 6.5 for cotton; hours per acre average 0.5 and 0.8, respectively. Less tillage time permits fuel and labor savings.

Tillage system designations for 1989 were determined from estimates of residue remaining after planting. The percent of residue remaining was estimated from the previous crop and the residue incorporation rates of the tillage implements.

Corn

Tillage practices used in 1989 corn production varied widely among the 10 major producing States (table 26). Wisconsin had the highest use of the moldboard plow (64 percent) to accommodate the corn/alfalfa rotations needed to support dairy farming. In Nebraska, the moldboard plow was used on only about 5 percent of the total corn acres. Nebraska does not have a preponderance of wet/heavy soils which require fall plowing. Furthermore, it has a more serious wind erosion problem than the other corn producing States. Overall, a moldboard plow was used on 19 percent of the 1989 corn acres.

Among the surveyed States, no-till systems were used on only 5 percent of the corn acres. At 18 percent, irrigated corn acreage in Nebraska had the highest proportion of acres under no-till, a figure which may reflect concern with wind

Table 26-Tillage practices used in corn production, 1989

Category	IL	IN	IA	MI	MN	MO	NE 1/	NE 2/	OH	SD	WI	Area
Planted acres (1000)	10900	5500	12700	2300	6200	2400	2325	5175	3400	3400	3600	57900
With cover crop (%)	7	10	1	14	6	6	11	7	12	5	9	6
	% of acres 3/											
Tillage system:												
Conv/w mbd plow 4/	9	21	14	30	28	9	8	3	36	18	64	19
Conv/wo mbd plow 5/	74	59	65	51	51	76	54	55	45	61	25	59
Mulch-till 6/	13	13	20	14	15	13	32	23	9	21	10	17
No-till 7/	4	6	1	5	6	3	6	18	11	nr	1	5
	% of soil surface covered											
Residue remaining after planting:												
Conv/w mbd plow	2	2	2	2	2	3	2	2	2	3	2	2
Conv/wo mbd plow	15	14	17	16	15	14	19	19	14	16	17	16
Mulch-till	38	39	36	39	36	38	38	38	39	38	40	38
No-till	55	64	id	78	65	id	70	65	70	nr	id	64
Average	18	18	19	18	17	18	27	31	18	18	11	19
	Number											
Hours per acre:												
Conv/w mbd plow	.6	.6	.7	.7	.8	.7	.7	.6	.9	.6	.9	.7
Conv/wo mbd plow	.4	.4	.4	.5	.4	.5	.5	.4	.5	.4	.6	.4
Mulch-till	.3	.3	.3	.5	.4	.4	.3	.3	.4	.4	.5	.3
No-till	.1	.1	id	.2	.1	id	.1	.2	.2	nr	id	.2
Average	.4	.4	.4	.5	.5	.5	.4	.4	.6	.4	.8	.5
Times over field:												
Conv/w mbd plow	4.2	3.8	4.2	3.9	4.4	4.0	3.2	3.7	3.9	3.7	4.1	4.1
Conv/wo mbd plow	3.5	3.5	3.4	3.5	3.7	3.7	3.8	3.7	3.5	3.5	3.6	3.5
Mulch-till	2.6	2.7	2.7	3.0	3.0	2.8	2.4	2.6	2.8	3.0	3.1	2.7
No-till	1.0	1.0	id	1.0	1.2	id	1.0	1.3	1.0	nr	id	1.3
Average	3.3	3.3	3.3	3.4	3.6	3.5	2.8	3.1	3.3	3.4	3.8	3.4

id = Insufficient data. nr = None reported.

1/ Nonirrigated. 2/ Irrigated. 3/ May not add to 100 due to rounding. 4/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 5/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 6/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 7/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

erosion. Nebraska had the highest State average residue level, due to the prevalence of non-moldboard plow tillage systems and extensive continuous corn production.

Ohio, at 11 percent, had the next highest acreage proportion under no-till. Ohio has traditionally had a high proportion of no-till acreage because of the emphasis placed on such systems by its agricultural agencies.

Cover crops are used for wind erosion protection, nutrient retention, and/or to reduce water erosion and moisture runoff. However, in extremely dry years, a cover crop may use up more moisture than it helps conserve. In the 10 major corn producing States, an average of 6 percent of the 1989 corn acreage also had a cover crop. The highest incidence was in Michigan (14 percent) where major concerns include wind erosion, water erosion, and nutrient retention.

Soybeans

The 14 major soybean producing States were divided into the northern and southern areas. The northern area reported 26 percent of its acres using conventional tillage with a moldboard plow, compared with only 4 percent in the southern area (tables 27 and 28). In contrast, 82 percent of southern area acreage used conventional tillage without the moldboard plow, compared with 51 percent of the northern area. Mulch tillage was more predominant in the northern than the southern area (18 vs. 5 percent), while no-tillage was more prevalent in the southern area (10 vs. 4 percent).

A reason for some of these differences may be found in the examination of rotation data. In the southern area, 50-90 percent of the previous acreage use consisted of soybeans or a fallow period (leaving fragile and limited residues). In the

Table 27--Tillage practices used in northern soybean production, 1989

Category	IL	IN	IA	MN	MO	NE	OH	Area
Planted acres (1000)	8800	4600	8300	5050	4400	2600	4000	37750
With cover crop (%)	3	8	4	6	5	6	6	5
				% of acres 1/				
Tillage system:								
Conv/w mbd plow 2/	26	39	20	41	6	nr	46	26
Conv/wo mbd plow 3/	55	40	53	39	74	55	41	51
Mulch-till 4/	16	13	24	14	17	42	6	18
No-till 5/	3	8	2	7	4	2	8	4
				% of soil surface covered				
Residue remaining after planting:								
Conv/w mbd plow	2	2	2	3	2	nr	2	2
Conv/wo mbd plow	18	16	19	18	14	18	12	17
Mulch-till	38	37	37	37	38	37	35	37
No-till	72	66	id	57	69	id	72	67
Average	18	17	21	17	19	27	14	19
				Number				
Hours per acre:								
Conv/w mbd plow	.5	.6	.6	.7	.9	nr	.9	.7
Conv/wo mbd plow	.5	.4	.5	.5	.5	.5	.6	.5
Mulch-till	.4	.3	.3	.4	.3	.3	.5	.4
No-till	.1	.1	id	.2	.1	id	.2	.2
Average	.5	.5	.5	.5	.4	.4	.7	.5
Times over field:								
Conv/w mbd plow	4.3	4.1	4.5	4.4	4.1	nr	4.4	4.3
Conv/wo mbd plow	4.1	3.9	4.1	5.0	3.9	3.8	4.2	4.1
Mulch-till	3.2	3.0	3.4	3.5	2.9	2.8	3.4	3.4
No-till	1.0	1.1	id	1.8	1.0	id	1.0	1.2
Average	3.9	3.7	3.9	4.3	3.7	3.3	4.0	3.9

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 28--Tillage practices used in southern soybean production, 1989

Category	AR	GA	KY	LA	MS	NC	TN	Area
Planted acres (1000)	3500	1200	1200	1950	2500	1550	1480	13380
With cover crop (%)	2	9	34	nr	2	11	7	7
				% of acres 1/				
Tillage system:								
Conv/w mbd plow 2/	1	6	8	1	nr	11	8	4
Conv/wo mbd plow 3/	91	76	45	97	95	63	73	82
Mulch-till 4/	5	11	9	2	2	7	5	5
No-till 5/	3	12	39	nr	3	20	15	10
Residue remaining after planting:				% of soil surface covered				
Conv/w mbd plow	id	2	2	id	nr	1	2	2
Conv/wo mbd plow	8	11	12	5	5	9	7	13
Mulch-till	48	38	40	id	id	38	42	42
No-till	65	71	68	nr	id	79	74	72
Average	11	19	35	7	9	24	18	15
				Number				
Hours per acre:								
Conv/w mbd plow	id	.9	.7	id	nr	1.0	.8	.8
Conv/wo mbd plow	.4	.5	.5	.5	.6	.7	.6	.6
Mulch-till	.4	.3	.3	id	id	.4	.2	.3
No-till	.1	.1	.2	nr	id	.2	.1	.1
Average	.4	.5	.4	.5	.6	.6	.6	.5
Times over field:								
Conv/w mbd plow	id	4.0	3.7	id	nr	4.7	4.3	4.3
Conv/wo mbd plow	5.1	3.5	4.1	5.4	4.9	3.9	4.8	4.8
Mulch-till	3.2	2.6	2.1	id	id	2.2	2.2	2.5
No-till	1.0	1.0	1.0	nr	id	1.0	1.0	1.0
Average	4.8	3.2	2.7	5.3	4.7	3.3	4.1	4.3

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting.
3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow.
4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

northern area, over 60 percent of the previous crop residue was corn, which leaves a hardier and heavier residue. Kentucky reported a high usage of no-till (39 percent) and is recognized as a leader in the advocacy and adoption of no-till systems.

The residue remaining under conventional tillage without the moldboard plow was higher in the northern area; for mulch-tillage and no-tillage, the residue was higher in the southern area. The hours per acre averaged 0.7 in the northern area and 0.8 in the southern area for conventional tillage with the moldboard plow, and the number of passes over the field were the same. For mulch tillage, the northern area averaged nearly one more trip over the field than the southern area.

The use of cover crops averaged 5 percent in the northern area. The average in the southern area was 7 percent, due to the higher use in Kentucky (34 percent) and North Carolina (11 percent). This incidence is related to the use of no-till.

Wheat

Oregon and Oklahoma reported the heaviest reliance on moldboard plows in winter wheat production (table 29). According to Extension personnel, some producers in Oregon believe that the risk of disease is intensified when large amounts of wheat residue are allowed to remain on the soil surface. Agricultural agencies in Oregon are researching this issue. Idaho reported greater-than-average use of the plow in producing spring wheat (table 30). Colorado and Montana reported more than 25 percent of their winter wheat acreage was produced with the use of mulch tillage.

The percent residue remaining after planting in most winter and spring wheat States came fairly close to the average for the area surveyed. California had the lowest remaining residue (7 percent) because of its greater use of conventional tillage methods, and Montana had the highest (26 percent) because of its extensive use of mulch-till and no-till methods.

Table 29--Tillage practices used in winter wheat production, 1989

Category	AR	CA	CO	ID	IL	IN	KS	MO	MT	NE	OH	OK	OR	TX	WA	Area
Harvested acres (1000)	1350	570	2100	810	1800	880	9600	1850	1700	2050	1200	5700	800	3000	1300	34710
							% of acres 1/									
Tillage system:																
Conv/w mbd plow 2/	nr	7	8	17	8	20	20	5	nr	10	18	33	42	1	11	16
Conv/wo mbd plow 3/	92	90	62	70	77	67	61	77	68	75	74	58	53	82	74	68
Mulch-till 4/	3	3	30	9	10	11	18	14	28	15	5	8	4	17	13	15
No-till 5/	5	nr	nr	3	4	2	1	4	4	nr	3	1	1	1	2	1
							% of soil surface covered									
Residue remaining after planting:																
Conv/w mbd plow	nr	1	1	3	2	3	2	2	nr	2	2	1	2	id	2	2
Conv/wo mbd plow	12	5	16	13	19	15	15	17	17	15	15	14	15	10	14	14
Mulch-till	id	id	41	44	40	40	39	41	41	39	id	44	id	38	35	35
No-till	id	nr	nr	id	id	id	id	id	id	nr	id	id	id	id	id	66
Average	16	7	23	15	22	16	16	22	26	18	15	12	10	15	17	17
							Number									
Hours per acre:																
Conv/w mbd plow	nr	id	.6	.5	.6	.6	.6	id	nr	.7	1.0	.7	.8	id	.7	.7
Conv/wo mbd plow	.4	.7	.5	.5	.3	.4	.6	.4	.4	.6	.5	.7	.5	.5	.5	.5
Mulch-till	id	id	.3	.4	.3	.3	.4	.3	.3	.5	id	.4	id	.4	.5	.4
No-till	id	nr	nr	id	id	id	id	id	id	nr	id	id	id	id	id	.1
Average	.4	.7	.5	.5	.3	.4	.5	.4	.3	.6	.6	.7	.6	.5	.5	.5
Times over field:																
Conv/w mbd plow	nr	id	5.5	3.4	3.6	3.5	5.7	id	nr	4.9	4.0	5.4	6.0	id	5.5	5.3
Conv/wo mbd plow	3.4	4.9	5.9	4.2	2.6	2.7	5.5	2.9	4.5	5.6	2.8	5.4	5.5	5.2	5.8	4.8
Mulch-till	id	id	4.4	3.8	2.3	2.3	4.8	2.3	3.2	3.5	id	4.0	id	4.6	5.1	4.1
No-till	id	nr	nr	id	id	id	id	id	id	nr	id	id	id	id	id	1.0
Average	3.3	4.8	5.4	3.9	2.6	2.8	5.4	2.8	4.0	5.2	3.0	5.3	5.6	5.0	5.6	4.7

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow.
4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system.
5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 30--Tillage practices used in spring and durum wheat production, 1989

Category	Spring wheat ID	Spring wheat MN	Spring wheat MT	Spring wheat ND	Spring wheat SD	Spring wheat Area	Durum wheat ND
Planted acres (1000)	580	2600	3500	7700	2200	16580	3000
With cover crop (%)	nr	21	nr	18	2	12	23
				% of acres 1/			
Tillage system:							
Conv/w mbd plow 2/	27	12	nr	10	10	9	4
Conv/wo mbd plow 3/	67	64	73	56	58	61	57
Mulch-till 4/	6	24	27	32	33	29	39
No-till 5/	nr	nr	nr	2	nr	1	1
Residue remaining after planting:				% of soil surface covered			
Conv/w mbd plow	2	2	nr	3	2	2	2
Conv/wo mbd plow	10	13	17	15	19	16	16
Mulch-till	id	39	43	40	39	40	43
No-till	nr	nr	nr	id	nr	id	id
Average	9	18	24	23	24	22	21
				Number			
Hours per acre:							
Conv/w mbd plow	.6	.9	nr	.3	.5	.5	.3
Conv/wo mbd plow	.5	.4	.3	.4	.3	.4	.4
Mulch-till	id	.3	.2	.2	.3	.2	.2
No-till	nr	nr	nr	id	nr	id	id
Average	.5	.4	.3	.3	.3	.3	.3
Times over field:							
Conv/w mbd plow	3.5	4.6	nr	2.9	2.8	3.3	4.2
Conv/wo mbd plow	3.2	4.3	4.5	4.3	3.0	4.1	5.0
Mulch-till	id	2.7	2.7	2.8	2.6	2.8	2.8
No-till	nr	nr	nr	id	nr	id	id
Average	3.3	3.9	4.0	3.6	2.8	3.6	4.1

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Except for the no-till systems, wheat acreage required more trips over the field than did corn acreage. Much of the wheat produced in the Great Plains and the Western States is produced after a fallow period. All implement passes made during the fallow year were included in determining residue levels, hours per acre, and trips over the field. Normal fallow procedure starts with chisel plowing and other noninversion tillage operations in the fall instead of a pass with the moldboard plow. For these States, therefore, the tables reflect more trips over the field under conventional tillage without the moldboard plow. North Dakota durum wheat acreage also shows this pattern because much of the durum wheat is planted after a fallow period.

North Dakota used cover crops on 23 percent of its durum wheat acreage and 18 percent of its spring wheat land. Minnesota reported use on 21 percent of its spring wheat acreage. Wind erosion protection and moisture retention benefits were probably of major concern in these States.

Cotton

Nearly all cotton is produced using conventional tillage methods in the six major cotton producing States (table 31). Use of the moldboard plow was quite minimal in four of these States. The plow was used most extensively in Arizona (66 percent of the acreage) and Texas (21 percent). Arizona and California have State plow-down laws requiring that the cotton plant be disposed of to eliminate the food source for bollworms and boll weevils. Many producers have interpreted these laws to mean that the previous crop must be plowed under or receive multiple diskings and other tillage. California producers mainly use multiple diskings with a heavy disk.

Arizona agricultural agencies currently advocate a reduction in the number of tillage operations, decreased use of the moldboard plow, and increased use of cover crops. These recommendations, which meet the legal requirements, are

Table 31--Tillage practices used in cotton production, 1989

Category	AZ	AR	CA	LA	MS	TX	Area
Planted acres (1000)	460	590	1069	650	1100	4575	8444
With cover crop (%)	4	13	2	14	0	9	9
				% of acres 1/			
Tillage system:							
Conv/w mbd plow 2/	66	nr	1	2	2	21	15
Conv/wo mbd plow 3/	34	95	99	98	98	79	84
Mulch-till 4/	nr	4	nr	nr	nr	nr	id
No-till 5/	nr	1	nr	nr	nr	nr	id
				% of soil surface covered			
Residue remaining after planting:							
Conv/w mbd plow	0	nr	id	id	id	.1	.1
Conv/wo mbd plow	.2	1.6	1.4	1.7	1.9	3.5	2.5
Mulch-till	nr	id	nr	nr	nr	nr	id
No-till	nr	id	nr	nr	nr	nr	id
Average	.1	3.8	1.3	1.6	1.9	2.8	2.3
				Number			
Hours per acre:							
Conv/w mbd plow	1.2	nr	id	id	id	.9	.9
Conv/wo mbd plow	1.3	.7	1.1	.7	.7	.6	.7
Mulch-till	nr	id	nr	nr	nr	nr	id
No-till	nr	id	nr	nr	nr	nr	id
Average	1.3	.6	1.2	.7	.7	.7	.8
Times over field:							
Conv/w mbd plow	8.4	nr	id	id	id	6.8	7.2
Conv/wo mbd plow	7.5	6.6	7.6	6.3	6.6	5.9	6.4
Mulch-till	nr	id	nr	nr	nr	nr	id
No-till	nr	id	nr	nr	nr	nr	id
Average	8.1	6.4	7.6	6.3	6.5	6.1	6.5

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

aimed at cutting input costs and preserving organic matter. Certain areas of Texas also have a plow-down law, and in some areas the moldboard plow is also used to bring up subsoil clay to cover the surface with clods to help control wind erosion.

The large number of tillage trips across the field (averaging 6.5) leaves very little residue, even without use of the moldboard plow. Research is being conducted in a number of cotton producing States on the use of mulch-till and no-till systems and the use of cover crops.

Cover crops were used on an average 9 percent of the acreage in the 6 major cotton producing States. The use of cover crops can be attributed to concern over moisture retention and protection from wind erosion.

Rice

Most of the rice acreage in Arkansas, California, and Louisiana is produced under conventional tillage without the moldboard plow (table 32). Erosion is not a problem in rice production because most rice is planted on flat, heavy-textured soils and then flooded. Cover crops were used on only 1 percent or less of the rice acreage. Rice seedbeds are nearly residue-free, partly because residue is perceived to harbor the disease organism that causes stem rot at the water line.

Highly Erodible Land

Corn production utilized the largest amount of HEL acreage in 1989, even though cotton and winter wheat had higher percentages of crop acres designated as HEL (table 33). Winter wheat and northern soybeans showed significantly less use of a moldboard plow on land designated HEL than on land designated non-HEL. On the other hand, the plow was used more extensively on cotton land designated as HEL.

With the exception of southern soybeans (54 percent), more than 66 percent of the 1989 cropland designated HEL (for the surveyed States and crops) utilized conventional tillage methods. This figure should change over the next few years, as approved conservation plans are implemented.

Table 32--Tillage practices used in rice production, 1989

Category	AR	CA	LA	Area
Planted acres (1000)	1150	415	520	2085
With cover crop (%)	1	1	1	1
		% of acres 1/		
Tillage system:				
Conv/w mbd plow 2/	nr	7	nr	1
Conv/wo mbd plow 3/	98	93	99	97
Mulch-till 4/	id	id	nr	id
No-till 5/	id	nr	id	id
Residue remaining after planting:		% of soil surface covered		
Conv/w mbd plow	nr	0	nr	0
Conv/wo mbd plow	4	1	4	3
Mulch-till	id	id	nr	id
No-till	id	nr	id	id
Average	5	1	5	4
		Number		
Hours per acre:				
Conv/w mbd plow	nr	id	nr	id
Conv/wo mbd plow	.5	id	.4	.5
Mulch-till	id	id	nr	id
No-till	id	nr	id	id
Average	.5	id	.4	.5
Times over field:				
Conv/w mbd plow	nr	6.4	nr	6.4
Conv/wo mbd plow	5.8	6.9	5.8	6.0
Mulch-till	id	id	nr	id
No-till	id	nr	id	id
Average	5.7	6.8	5.8	6.0

id = Insufficient data. nr = None reported.

1/ May not add to 100 due to rounding. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 33--Erodibility distribution of crop acreage and tillage systems, 1989

Category	Winter wheat 1/	Corn	Northern soybeans	Southern soybeans	Cotton	Spring wheat	Durum wheat	Rice
Planted acres (1000)	34710	57900	37750	13380	8444	16580	3000	2085
Highly erodible land (%)	22	18	14	7	25	15	13	2
Land not highly erodible (%)	62	71	77	76	59	76	71	77
Land not designated (%)	16	11	9	17	16	9	16	21
Highly erodible land:								
Planted acres (1000)	7545	10540	5305	996	2102	2502	403	40
				Percent				
Tillage system:								
Conv/w mbd plow 2/	10	16	8	4	28	12	nr	17
Conv/wo mbd plow 3/	67	51	64	50	72	58	78	83
Mulch-till 4/	21	26	22	8	nr	30	22	nr
No-till 5/	2	7	6	38	nr	nr	nr	nr
Land not highly erodible:								
Planted acres (1000)	21672	41020	29193	10088	4956	12557	2127	1608
				Percent				
Tillage system:								
Conv/w mbd plow 2/	20	19	29	2	9	6	4	id
Conv/wo mbd plow 3/	66	61	49	88	90	64	49	98
Mulch-till 4/	13	15	18	4	id	30	46	id
No-till 5/	1	5	4	6	id	id	1	id
Land not designated								
Planted acres (1000)	5393	6240	3252	2296	1385	1521	470	437
				Percent				
Tillage system:								
Conv/w mbd plow 2/	9	26	30	10	19	23	5	id
Conv/wo mbd plow 3/	79	56	60	72	81	49	76	95
Mulch-till 4/	11	11	8	4	nr	28	19	nr
No-till 5/	1	7	2	14	nr	nr	nr	id

id = Insufficient data. nr = None reported.

1/ Harvested acres for winter wheat only. 2/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30% residue remaining after planting. 3/ Conventional tillage without moldboard plow--any tillage system that has less than 30% remaining residue and does not use a moldboard plow. 4/ Mulch-tillage--System that has 30% or greater remaining residue after planting and is not a no-till system. 5/ No-tillage--No residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Seeds

Consumption

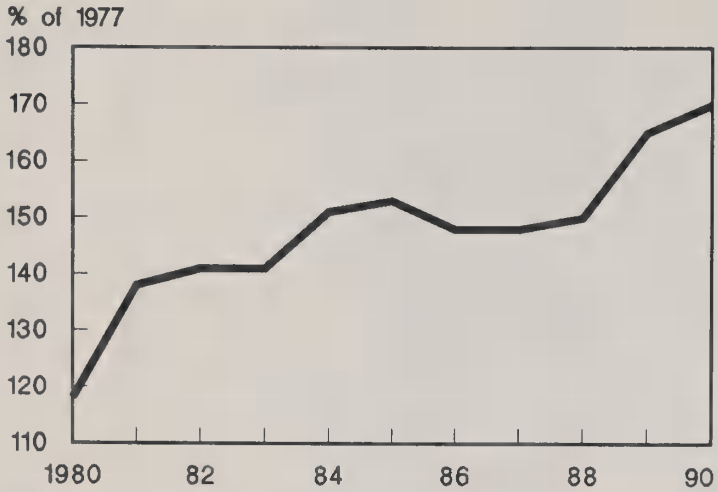
Seed consumption was up in the 1989 crop year for the eight major field crops. It reached 6.5 million tons, up 10 percent from a year earlier due to an increase in planted acreage (table 34). Since seeding rates tend to change slowly from year to year, the number of acres planted is the major determinant of seed consumption. In 1990 crop year, seed use for the eight major crops will likely equal 6.7 million tons; this figure represents a gain of only 3 percent from the previous year, due to modest expansion in planted acreage.

Table 34--Seed use for major U.S. field crops 1/

Crops	1986/87	1987/88	1988/89	1989/90 2/	Change 88/89-89/90
	1,000 tons				Percent
Corn	468	482	523	540	3
Sorghum	45	39	43	43	-1
Soybeans	1,653	1,684	1,766	1,695	-4
Barley	430	377	360	371	3
Oats	450	467	473	483	2
Wheat	2,520	2,550	3,090	3,275	6
Rice	130	150	150	160	7
Cotton	93	106	89	105	18
Total	5,789	5,855	6,494	6,672	3

1/ Crop marketing year. 2/ Projected.

Figure 1
Seed Price Index



1990 forecast.

Prices

Field seed prices rose in 1989. Most seed prices were boosted significantly by greater demand resulting from increased planted acreage, drought-reduced seed supply, higher commodity prices, and increased cost of off-season production. For example, soybean and hybrid corn seed prices rose about 24 and 11 percent, respectively, between 1988 and 1989. Forage seed prices also increased in 1989, as Conservation Reserve Program (CRP) acres continued to expand. USDA's price paid index for seed rose 10 percent in 1989 but will likely remain near year-earlier levels in 1990 as the growth in CRP acreage slows and seed supplies are expected to be more abundant (fig. 1). Seed prices for non hybrid crops tend to follow commercial crop prices.

Seeding Rates and Seed Costs Per Acre

Average seed cost per acre increased in 1989, but seeding rates were similar to the previous year. Seeding rate and seed price primarily determine seed cost per acre. Costs vary substantially by State and crop. Locations where crops are mostly irrigated (as in California) or where rain is normally abundant (as in the eastern Corn Belt) support heavier seeding rates, thereby raising seed costs per acre.

Corn

The average seeding rate for the 10 leading corn producing States in 1989 was 24,100 kernels per acre, similar to 1988. In 1989, the average seed cost per acre was $20.40 (table 35), up 9 percent from a year earlier, reflecting higher corn seed prices. The plant population per acre for the 10 States increased 1 percent in 1989 because of favorable weather conditions. In 1988, the drought reduced plant population 6 percent from a year earlier.

Table 35--Corn for grain seeding rates, plant population, and seed cost per acre, 1989 1/

States	Acres planted	Rate per acre	Plant population per acre	Cost per acre
	Thousand	Kernels	Number	Dollars
IL	10,900	24,900	21,900	20.61
IN	5,500	24,500	21,500	20.08
IA	12,700	23,900	21,600	20.93
MI	2,300	23,900	21,100	20.35
MN	6,200	26,000	24,100	23.09
MO	2,400	21,400	17,900	18.38
NE	7,500	24,400	20,700	20.86
OH	3,400	26,000	21,400	21.98
SD	3,400	17,900	16,400	14.36
WI	3,600	24,000	21,000	18.42
1989 average	57,900	24,100	20,760	20.40
1988 average	53,200	24,100	20,610	18.64

1/ States planted 80 percent of U.S. corn acres in 1989.

Table 36--Soybean seeding rates, seed cost per acre, and percent seed purchased, 1989 1/

States	Acres planted	Rate per acre	Cost per acre 2/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
Northern:				
IL	8,800	59	16.12	69
IN	4,600	59	15.46	74
IA	8,300	57	16.78	70
MN	5,050	67	15.36	58
MO	4,400	59	14.48	65
NE	2,600	61	16.92	73
OH	4,000	75	19.43	75
Average	37,750	61	16.30	69
Southern:				
AR	3,500	54	11.69	53
GA	1,200	45	10.24	64
KY	1,200	61	14.90	61
LA	1,950	54	15.75	97
MS	2,500	55	12.69	80
NC	1,550	59	14.87	65
TN	1,480	50	11.18	56
Average	13,380	54	12.94	68
1989 average	51,130	60	15.52	68
1988 average	48,750	62	12.86	73

1/ States planted 85 percent of U.S. soybean acres in 1989. 2/ Based on data from those farmers who used purchased seed.

The seeding rate (and therefore seed cost per acre) varied considerably across the Corn Belt, primarily because of soil productivity and moisture availability. For example, Minnesota had the highest seeding rate and cost per acre; South Dakota, on the other hand, typically has lower and more variable precipitation than other corn growing States, thus lowering seeding rates.

Soybeans

The average seeding rate for the 14 major soybean producing States was 60 pounds per acre in 1989, down slightly from 1988. The average seed cost per acre was $15.52 (table 36), up 21 percent due to higher seed prices. The northern soybean States (Illinois, Ohio, Nebraska, and Minnesota), which have higher seeding rates and yields, exhibit

greater seed costs. Seeding rates tend to be lower in the southern States such as Georgia, Tennessee, Arkansas, Mississippi, and Louisiana, and they consequently have lower seed costs per acre.

Farmers in the surveyed States used purchased rather than homegrown soybean seed on 68 percent of soybean acres in 1989. The share of purchased seed totaled 73 percent in both 1988 and 1987. The share of 1989 acres sown with purchased seed varied widely among surveyed States, ranging from 53 percent in Arkansas to 97 percent in Louisiana. Differences in seed cost and yield greatly influence the decision to use purchased rather than homegrown seed.

Winter Wheat

The average seeding rate per acre for winter wheat was 77 pounds in 1989, up 3 percent from 1988. But the average cost was $9.59 per acre, up 25 percent from 1988 due to higher seed prices and seeding rates per acre (table 37). Ohio, Indiana, California, Illinois, Arkansas, and Missouri had the highest seeding cost per acre, reflecting higher seeding rates. Colorado had the lowest seeding rate and cost per acre. In 1989, farmers sowed 41 percent of the wheat acreage with purchased seed, down from 53 percent in 1988. However, in 1987 and 1986 the percent of wheat acreage planted with purchased seed totaled 40 percent, about the same as in 1989.

Table 37--Wheat seeding rates, seed cost per acre, and percent of seed purchased, 1989 1/

States	Area	Rate per acre	Cost per acre 2/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
Winter:				
AR	1,350	128	13.92	54
CA	570	134	15.11	79
CO	2,100	44	3.63	41
ID	810	86	9.78	70
IL	1,800	105	14.72	66
IN	880	117	16.86	76
KS	9,600	61	6.56	33
MO	1,850	112	12.94	49
MT	1,700	56	4.91	25
NE	2,050	63	6.04	28
OH	1,200	136	18.16	60
OK	5,700	75	7.04	26
OR	800	79	9.64	65
TX	3,000	73	7.91	37
WA	1,300	66	8.12	71
1989 average	34,710	77	9.59	41
1988 average	32,830	75	7.67	53
Spring:				
ID	580	101	13.72	73
MN	2,600	108	11.44	53
MT	3,500	63	5.73	35
ND	7,700	92	8.37	36
SD	2,200	88	7.97	37
1989 average	16,580	89	8.82	40
1988 average	9,780	90	8.58	46
Durum:				
ND	3,000	99	10.13	47
1989 average	3,000	99	10.13	47
1988 average	2,500	99	8.05	47

1/ States harvested 84 percent of U.S. winter wheat acres, planted 93 percent of U.S. spring wheat and 82 percent of U.S. durum wheat acres in 1989. 2/ Based on data from those farmers who used purchased seed.

Spring and Durum Wheat

The average spring wheat seeding rate in 1989 was 89 pounds, similar to 90 pounds in 1988 and 88 pounds in 1987. Although the seeding rate was slightly lower, average seed cost per acre reached $8.82, up 3 percent from 1988 because of higher seed prices (table 37).

Average seed cost and seeding rates, however, varied considerably among surveyed States. Idaho had the highest seed cost per acre--$13.72, with a seeding rate of 101 pounds per acre. At 63 pounds, Montana had the lowest seeding rate per acre, and consequently the lowest seed cost--$5.73 per acre. In 1989, spring wheat acres planted with purchased seed averaged 40 percent.

The average seed cost for durum wheat in 1989 was $10.13 per acre, up 26 percent from 1988 (table 37) because of higher seed prices. The seeding rate and the acreage planted with purchased seed were the same as a year earlier.

Rice

In 1989, the average seeding rate for rice was 134 pounds per acre, 2 percent higher than 1988, and the average seed cost was $19.87, down 26 percent due to lower rice seed prices (table 38). Also, the average percent of acres planted with purchased seed declined in 1989 from a year earlier. California had the highest seeding rate, while Louisiana had the highest cost per acre, reflecting higher seed prices in Louisiana than California. In each of these States, 91 percent of the acreage was planted with purchased seed; in Arkansas, on the other hand, only 76 percent of the acreage was planted with purchased seed.

Table 38--Rice seeding rates, seed cost per acre, and percent of seed purchased, 1989 1/

States	Acres planted	Rate per acre	Cost per acre 2/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
AR	1,150	124	17.79	76
CA	415	162	20.39	91
LA	520	132	23.06	91
1989 average	2,085	134	19.87	83
1988 average	2,130	131	26.22	87

1/ States planted 75 percent of U.S. rice acres in 1989. 2/ Based on data from those farmers who used purchased seed.

Table 39--Cotton seeding rates, seed cost per acre, and percent seed purchased, 1989 1/

States	Acres planted	Rate per acre	Cost per acre 2/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
AZ	460	15	8.29	93
AR	590	14	7.31	95
CA	1,069	17	11.07	87
LA	650	14	8.67	100
MS	1,100	14	7.69	100
TX	4,575	21	7.43	54
1989 average	8,444	18	8.17	67
1988 average	9,700	18	8.38	86

1/ States planted 80 percent of U.S. cotton acres in 1989. 2/ Based on data from those farmers who used purchased seed.

Cotton

In 1989, the average seeding rate for cotton was 18 pounds per acre, the same as last year. The average seed cost was $8.17 per acre, lower than last year due to lower seed prices (table 39). Although California had a lower seeding rate than Texas, its seed cost per acre was higher due to higher prices. Texas, on the other hand, had the highest seeding rate (21 pounds per acre), but its cost per acre was very close to the lowest.

U.S. Planting Seed Trade

Corn Seed Exports

The decline of domestically produced field corn seed engendered by the 1988 drought has sharply reduced the volume of exports to the major importing countries. Total U.S. field corn exports equaled 19,491 metric tons in the first 9 months of 1989, 13 percent lower than in the corresponding period a year earlier (table 40). Exports to the Netherlands, Turkey, Chile, Spain, France, Italy, and Greece declined 80, 78, 37, 47, 32, 23, and 20 percent, respectively, in the first 9 months of 1989 compared with the corresponding period of 1988.

Table 40--U.S. seed corn exports by volume

Country	1986	1987	1988	January-September 1988	January-September 1989	Change 88-89
	Metric tons					Percent
Canada	1,621	2,505	2,582	2,219	1,311	-41
Mexico	3,703	3,143	3,151	2,931	7,166	144
Chile	64	166	541	531	333	-37
Argentina	867	699	808	808	1,196	48
France	2,121	2,542	2,439	1,128	766	-32
Spain	1,245	2,049	4,134	2,483	1,320	-47
Italy	7,939	12,229	8,741	3,341	2,589	-23
Netherlands	5,127	695	1,060	351	71	-80
Greece	3,088	1,894	2,251	2,200	1,759	-20
Turkey	3,224	2,678	1,104	1,107	245	-78
Japan	720	1,861	1,322	641	756	18
Subtotal	29,719	30,461	28,133	17,740	17,512	-1
Total	44,662	32,412	33,547	22,283	19,491	-13

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 41--U.S. corn seed imports by volume

Country	1986	1987	1988	January-September 1988	January-September 1989	Change 88-89
	Metric tons					Percent
Canada	8,102	4,465	3,988	2,309	4,125	79
Argentina	71	0	0	0	2,457	in
Chile	14	67	2,055	2,055	7,000	241
Hungary	271	196	1,327	35	3,708	10,494
Subtotal	8,458	4,728	7,370	4,399	17,290	293
Total	8,500	4,754	7,909	4,586	19,021	315

in = Inapplicable.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

However, corn seed exports to Mexico, Argentina, and Japan increased in the first 9 months of 1989 over the same period a year earlier. The volume exported to Mexico jumped from 2,931 metric tons in the first 9 months of 1988 to 7,166 metric tons in 1989. Mexico also experienced severe drought in 1988, which sharply reduced its corn seed production and necessitated greater imports.

Corn Seed Imports

U.S. corn seed imports rose between the first 9 months of 1988 and 1989 to supplement the drought-reduced domestic supply. Total corn seed imports soared from 4,586 metric tons a year earlier to a record 19,021 metric tons, a jump of 315 percent (table 41).

Canada has traditionally been the largest supplier of corn seed to the United States, while Argentina, Chile, and Hungary have exported widely varying quantities. During the first 9 months of 1989, imports from Canada rose 79 percent by volume from the corresponding period a year earlier. Several companies grew corn seed in South America during the off-season, and much of the production entered the United States during the first 9 months of 1989. Argentina supplied 2,457 metric tons of corn seed during that period, although it had exported no corn seed to the United States in the previous 3 years. Imports from Chile surged by 241 percent in the first 9 months of 1989 over the corresponding period of 1988, while those from Hungary soared from 35 to 3,708 metric tons.

Soybean Seed Exports

Soybean seed exports declined to major importers except Mexico. Despite drought-reduced U.S. soybean seed supplies, exporters were generally able to meet their 1989 commitments. Exports to some countries such as France, Turkey, South Korea, and Japan--some of the major importers--declined 32, 27, 100, and 57 percent, respectively, in the first 9 months of 1989 compared with corresponding period of 1988 (table 42). Exports to Italy, the largest market, decreased in 1988 from the record 44,348 metric tons of 1987. Although exports to Italy increased 10 percent in the first 9 months of 1989 over the corresponding period a year earlier, total exports for the entire 1989 calendar year are

Table 42--U.S. soybean seed exports by volume

Country	1986	1987	1988	January-September 1988	January-September 1989	Change 88-89
	Metric tons					Percent
Canada	1,510	6,087	292	134	390	191
Mexico	1,515	12,630	8,922	1,709	91,063	5,228
France	2,073	1,404	2,147	1,754	1,196	-32
Italy	22,522	44,348	26,728	12,946	14,266	10
Turkey	5,879	5,038	3,798	3,798	2,777	-27
South Korea	2	0	2,000	2,000	0	in
Japan	2,934	4,151	5,277	293	126	-57
Subtotal	36,435	73,658	49,164	22,634	109,818	385
Total	37,317	75,164	53,730	25,210	110,959	340

in = Inapplicable

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

unlikely to match those of 1988 due to unresolved phytosanitary issues.

Despite lower U.S. supplies and higher seed prices, soybean seed exports to Mexico for the first 9 months of 1989 equaled 91,063 metric tons, up sharply from 1,709 metric tons for the same period of 1988. Mexico's seed supply was also reduced by the 1988 drought. The surge in exports to Mexico more than offset the combined declines in exports to other major U.S. trading partners. As a result, total U.S. soybean seed exports to seven major importers jumped from 22,634 metric tons in the first 9 months of 1988 to 109,818 metric tons in the corresponding period of 1989. Without this increase, U.S. soybean seed exports would have declined 17 percent.

Total Exports

The U.S. planting seed trade surplus surged during the first 9 months of 1989. The value of total seed exports rose 27 percent from the corresponding period of 1988 to $348 million (table 43). This increase primarily reflects gains in soybean, grain sorghum, flower, and forage seeds, which went up 292, 111, 50, and 2 percent, respectively. The sharp increase in soybean seed exports by value (despite reduced U.S. supplies) stems primarily from the jump in Mexico's imports. These gains were partly offset by respective declines of 18 and 16 percent in corn and vegetable seed exports.

Mexico, Italy, Japan, Canada, France, and the Netherlands continued to be the top markets for U.S. planting seeds in calendar year 1988, accounting for about 55 percent of the total export value (table 44). Mexico (with 13 percent of the total) held first place, followed by Italy (12.5 percent), Japan (12 percent), Canada (8 percent), France (4.6 percent), and the Netherlands (4.5 percent). On a regional basis, Western Europe, North and Central America, and Asia typically account for over 80 percent of the total seed export value.

Total Imports

Imports reached $137 million in the first 9 months of 1989, up 23 percent from the corresponding period of 1988. These gains can be largely attributed to the $27-million increase in corn seed import value. U.S. corn seed imports rose sharply to make up for the drought-reduced supplies of 1988. These

Table 43--Exports and imports of U.S. seed for planting 1/

Item	1986	1987	1988	January-September 1988	January-September 1989	Change 88-89
	$ million					Percent
Exports:						
Forage	74	75	94	63	64	2
Vegetable	128	138	167	110	92	-16
Flower	9	8	9	4	6	50
Corn 2/	77	63	66	44	36	-18
Grain sorghum	29	16	29	19	40	111
Soybean	19	36	26	12	47	292
Tree/shrub	2	2	3	2	2	0
Sugarbeet	2	1	2	1	1	0
Other	31	33	26	17	60	253
Total	371	372	422	274	348	27
Imports:						
Forage	39	65	52	41	36	-12
Vegetable	42	49	58	44	44	0
Flower	18	21	21	14	17	21
Corn 3/	9	5	10	5	32	540
Tree/shrub	1	1	2	1	1	0
Other	3	4	4	5	7	40
Total	112	146	147	111	137	23
Trade balance	250	226	275	163	211	29

1/ Totals may not add due to rounding. 2/ Not sweet, not food aid. 3/ Certified.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 44--Export values for U.S. seeds for planting, region and country share 1/

Region/country	1984	1985	1986	1987	1988
			Percent		
North and Central America:					
Canada	8.9	7.4	6.3	9.4	8.4
Mexico	19.6	15.1	12.4	13.0	12.8
Others	2.7	2.5	2.0	2.3	2.2
Total	31.3	25.0	20.7	24.7	23.3
South America:					
Brazil	1.0	1.1	1.1	1.2	1.2
Argentina	2.0	1.1	2.5	2.5	3.0
Colombia	1.4	0.8	1.0	0.9	1.1
Venezuela	2.2	2.9	3.0	1.4	3.4
Others	2.1	1.1	1.3	1.5	0.8
Total	8.7	7.0	9.0	7.6	10.2
Western Europe:					
United Kingdom	2.2	2.7	2.8	2.6	2.9
Netherlands	3.5	4.6	5.8	5.4	4.5
France	4.1	9.6	6.2	4.5	4.6
West Germany	1.7	1.8	1.7	1.6	1.5
Spain	1.3	1.4	1.6	2.1	4.4
Italy	8.3	12.5	12.7	19.3	12.5
Greece	1.4	1.9	2.3	1.3	1.8
Others	3.9	3.1	3.4	2.8	3.2
Total	26.4	37.5	36.5	39.7	35.4
Eastern Europe:					
Hungary	0.1	2.9	0.6	0.1	0.4
Bulgaria	0.0	0.0	3.0	0.0	0.0
Others	0.4	0.4	1.2	0.1	0.8
Total	0.5	3.3	4.8	0.2	1.3
Asia:					
Turkey	0.7	1.3	3.0	2.0	1.0
Iraq	3.3	2.5	2.2	1.8	2.4
Saudi Arabia	4.5	2.8	3.6	2.0	4.2
Japan	11.4	10.7	9.6	12.3	11.9
South Korea	1.5	0.8	0.9	1.0	1.0
Others	5.0	3.8	4.6	3.6	3.5
Total	26.4	21.9	23.9	22.6	24.7
Africa:					
South Africa	1.3	0.8	1.2	1.5	1.1
Egypt	1.2	1.0	0.6	0.8	0.8
Others	2.1	1.1	1.4	0.7	1.0
Total	4.7	2.9	3.2	3.0	3.0
Oceania:					
Australia	1.5	2.0	1.6	1.8	1.7
New Zealand	0.4	0.4	0.3	0.3	0.3
Others	0.0	0.0	0.0	0.1	0.0
Total	2.0	2.4	1.9	2.2	2.0
Total	100.0	100.0	100.0	100.0	100.0

1/ Totals may not add due to rounding.

gains were partly offset by a 12-percent decline in forage seed imports. The U.S. seed trade balance surged 29 percent to $211 million in the first 9 months of 1989 over the same period a year earlier (table 43).

In calendar year 1988, Canada continued to be the leading U.S. supplier of planting seeds, with 30 percent of the total seed imports (table 45). The Netherlands, with 9 percent, remained the second largest source, followed by India (8 percent) and Japan (6 percent). Taiwan supplied 5 percent of 1988 total seed imports; in calendar year 1987, it held second place with 7 percent of the total.

Among regions, the largest share of seed imports came from North and Central America, which accounted for 36 percent of the total. Asia remained the second leading source of imports, with 25 percent (up from 19 percent in 1987). Western Europe supplied 17 percent of the total imports.

Table 45--Import values for U.S. seeds for planting, region and country share 1/

Region, country	1984	1985	1986	1987	1988
North and Central America:			Percent		
Canada	23.5	26.7	35.1	37.7	30.4
Mexico	2.5	4.0	2.9	2.0	2.1
Guatemala	2.6	2.3	2.7	2.5	2.4
Costa Rica	4.1	4.8	2.6	2.1	0.7
Others	0.3	0.6	0.1	0.1	0.1
Total	33.0	38.5	43.4	44.4	35.8
South America:					
Chile	9.0	8.2	6.2	4.0	6.8
Others	0.3	1.0	0.8	2.0	1.5
Total	9.3	9.2	7.0	6.0	8.3
Western Europe:					
Denmark	0.7	1.6	1.2	2.1	1.9
United Kingdom	0.6	0.8	0.6	0.8	0.6
Netherlands	9.6	11.7	10.5	10.2	9.2
France	1.2	1.4	1.1	1.7	1.0
West Germany	1.2	1.4	2.2	2.5	2.2
Italy	1.0	1.7	1.1	1.2	1.6
Others	0.8	2.4	1.9	0.7	0.3
Total	15.1	21.0	18.7	19.2	16.8
Eastern Europe:					
Yugoslavia	0.7	1.4	0.0	0.0	0.0
Romania	4.8	0.2	0.1	0.0	0.0
Hungary	0.0	0.0	0.0	0.0	1.2
Others	1.0	0.2	0.4	0.5	0.1
Total	6.5	1.8	0.4	0.5	1.3
Asia:					
India	1.5	3.3	6.5	2.9	7.5
Taiwan	9.1	7.6	6.0	6.7	4.5
Japan	5.3	6.1	6.1	6.0	6.4
China (Mainland)	0.0	0.0	0.0	0.0	2.4
Others	3.3	3.0	3.6	3.8	3.7
Total	19.2	20.1	22.2	19.4	24.5
Africa:					
Ethopia	3.0	4.4	2.8	3.0	3.3
South Africa	1.6	0.9	0.5	0.1	0.5
Others	0.5	1.0	0.6	0.8	0.6
Total	5.1	6.4	4.0	3.9	4.4
Oceania:					
Australia	1.2	2.2	1.8	2.1	1.8
New Zealand	0.6	0.8	2.6	4.5	5.6
Others	0.0	0.0	0.0	0.0	0.0
Total	1.8	3.0	4.3	6.5	7.4
Total	90.0	100.0	100.0	100.0	100.0

1/ Totals may not add due to rounding.

Energy

U.S. farmers can expect 1990 energy prices to remain at or perhaps slightly above 1989 prices due to the expected steady price of imported crude oil. Direct energy expenditures by farmers (which comprise about 5.5 percent of total farm production expenses) are expected to rise 4.6 percent to $9.09 billion; this increase can be attributed to heightened fuel use necessitated by the expansion of planted acreage.

Petroleum Consumption and Production

In September 1989, ministers of the Oil Producing and Exporting Countries (OPEC), meeting in Geneva, could not agree to limit members' crude oil production. As a result, it is expected that OPEC crude oil production in 1990 will almost equal the generally perceived demand for OPEC crude oil of about 22.5 million barrels per day. If this production scenario is realized, there will be little or no change in the price of crude oil.

Total consumption of petroleum for 1989 in the world market economies increased by approximately 2.1 percent to 51.6 million barrels per day over 1988, the largest gain since 1979. In 1990, world crude oil consumption is predicted to rise 2.1 percent.

The U.S. Department of Energy (DOE) forecasts that the quantity of petroleum consumed in the United States will average 130,000 barrels per day more in 1990 (up 0.8 percent from the 1989 level), due mainly to heightened demand for home heating oil and transportation fuel (table 46).

U.S. refiners paid an average $17.62 per barrel for the first 8 months in 1989 for domestically produced crude oil processed, up 19.5 percent from the $14.74 per barrel for all of 1988. The price reached the 1989 yearly high of $19.02 in May. The average imported price of crude oil paid by refiners, at $17.81 per barrel, was only slightly higher than the domestic price. This figure will likely fall to $17.50 for 1990 (fig. 2). There is some uncertainty in this forecast since it can be greatly affected by vagaries in OPEC production behavior and the weather.

Table 46--U.S. petroleum consumption-supply balance

Item	1987	1988	1989	Forecast 1990
	Million barrels/day			
Consumption:				
Motor gasoline	7.21	7.34	7.34	7.41
Distillate fuel	2.98	3.12	3.12	3.17
Residual fuel	1.26	1.38	1.31	1.19
Other petroleum 1/	5.22	5.45	5.48	5.64
Total	16.67	17.29	17.25	17.41
Supply:				
Production 2/	10.65	10.51	10.01	9.77
Net imports (includes SPR) 3/	5.91	6.59	7.19	7.61
Net stock withdrawals	0.04	0.19	0.05	0.04
Total	16.60	17.29	17.25	17.42
	Percent			
Net imports as a share of total supply	35.60	38.18	41.61	43.69
	% change from previous year			
Consumption		3.72	0.02	0.93
Production		-1.31	-4.76	-2.40
Imports		11.51	9.10	5.84

SPR = Strategic Petroleum Reserves.

1/ Includes crude oil product supplied, natural gas liquid (NGL), other hydrocarbons and alcohol, and jet fuel. 2/ Includes domestic oil production, NGL, and other domestic processing gains (i.e., volumetric gain in refinery cracking and distillation process). 3/ Includes both crude oil and refined products.

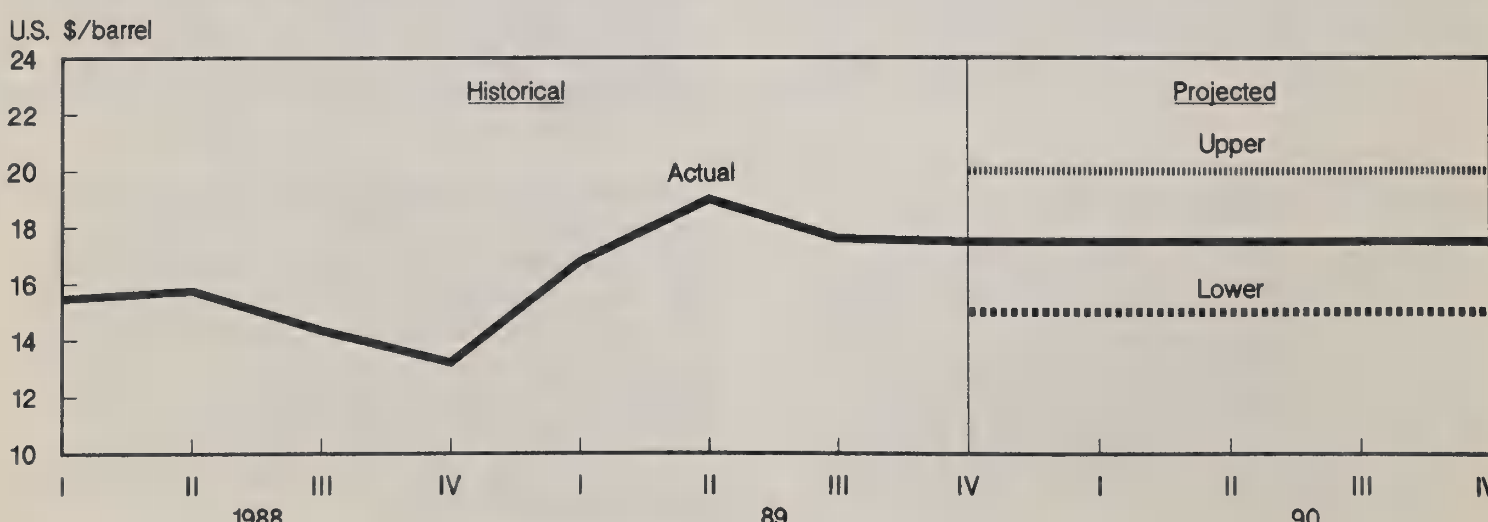
Source: U.S. Department of Energy, Energy Information Administration. Short-Term Energy Outlook. DOE/EIA-0202(89/4Q). October 1989.

Domestic production of crude oil will likely decline for the fifth consecutive year in 1990 to 7.37 million barrels per day, down 300,000 barrels (a 3.9 percent fall) from 1989 and the lowest level in 25 years (table 46). Its price appears still insufficient to cover production expenses and yield adequate returns in many high-cost U.S. fields. Expanding demand and declining domestic production are expected to boost U.S. net imports of crude oil by 5.8 percent to 7.61 million barrels per day, or 43.7 percent of domestic consumption, in 1990 (table 46). This estimate may be compared with the record high import level of 8.56 million barrels per day in 1977 (45.4 percent of domestic consumption) and the low of 4.29 million barrels per day in 1985 (27.2 percent of domestic consumption).

Slight upward movements in average energy prices are expected on an annual basis between 1989 and 1990, reflecting not only the stable outlook for crude oil prices (fig. 2) but also the anticipated increase in the demand for home heating oil prompted by the unusually cold weather. Energy prices are unlikely to be affected by the Appalachian coal strike (recently settled in principle, although the details have yet to be resolved). The refinery shutdown in St. Croix, the Virgin Islands caused by Hurricane Hugo in September produced temporary upward movements in the prices of refined petroleum products. The shutdown's impact was exacerbated by the colder-than-normal weather, since the plant produces about 50,000 barrels of home heating oil per day (about 16.0 percent of total U.S. consumption).

The cold weather in December had a significant impact on the price of home heating oil in December 1989 with the effect carrying over to January 1990. For example, in parts of the eastern United States, home heating oil prices increased from 50 to 100 percent between late November 1989 and early January 1990. The magnitude of the increase was a function of suppliers' inventories (which were generally inadequate) and their access to additional supplies. The price increases were the largest in the New England region where the most severe shortages occurred. Also, the price of gasoline increased as refiners tilted their product mix to satisfy the increased demand for home heating oil. By late January 1990, however, there was a rebound in both gasoline and home heating oil supplies (inventories) resulting in a fall

Figure 2
Imported Crude Oil Price



in the price of both refined petroleum products from their levels earlier in the month. An expectation of slightly above average temperatures across the United States coupled with the increase in inventories has resulted in the commodity futures prices for both gasoline and home heating oil returning almost to their 1989 seasonal levels.

Energy In the Farm Sector

The U.S. agricultural sector's energy supply and price expectations reflect world crude oil market conditions. Currently, as noted above, world oil supplies are abundant and this situation is expected to continue through 1990. Fuel prices in the farm sector increased in 1989 from 1988, but they are expected to stabilize in 1990 at or slightly above 1989 levels. Farmers can expect plentiful supplies of gasoline, diesel fuel, and liquified petroleum (LP) gas in 1990. There was a severe shortage of LP gas in some eastern regions of the United States during December 1989 and January 1990 (especially affecting the broiler industry on the Delaware-Maryland-Virginia peninsula) that was a function of the cold weather that gripped the Atlantic seaboard during December. By early February 1990, suppliers were able to alleviate this shortage although the LP gas price remains somewhat above its historical seasonal level. The price is expected to return to normal shortly.

Farm Fuel Use

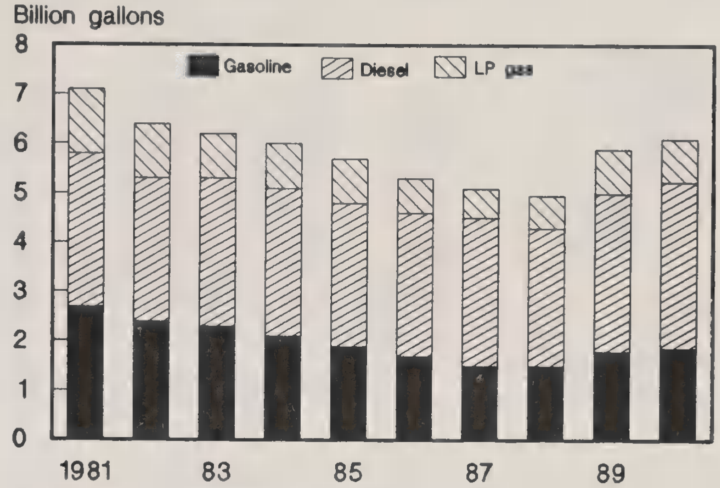
Although the agricultural sector accounts for only about 4 percent of total direct energy consumption in the United States, energy is essential nonetheless since farm operations are highly mechanized.

Agricultural consumption of refined petroleum products (including gasoline and diesel fuel) and LP gas has declined steadily since 1981 (fig. 3). Although the number of acres planted influence farm energy use, other factors are also important. For example, the switch from gasoline- to diesel-powered engines; conservation tillage practices; larger, multifunction machines; and innovations in crop drying and irrigation have contributed to this decline. While no-till and mulch-till farming practices have not yet been widely adopted, they are now as prevalent as conventional tillage practices in several parts of the country. With only a modest increase in the number of planted acres forecast for 1990, farm energy use will likely remain near or slightly above the levels forecast for 1989.

Energy Prices Rose In 1989

Crude oil prices (especially that of imported crude oil, since it is the marginal supply in most instances) heavily influence the prices farmers pay for refined petroleum products, such as gasoline and diesel fuel. In fact, historically each 1-percent increase in the price of imported crude oil in the United States has translated into about a 0.7-percent rise in the price of gasoline and diesel fuel paid by farmers. In 1989, average gasoline prices jumped by 13 percent and diesel fuel prices rose by 4 percent over their 1988 levels (table 47). These gains can be attributed to refiners' higher costs of acquiring crude and reducing vapor emissions. Only a slight rise in energy prices is expected for the remainder of 1990.

Figure 3
Farm Fuel Use



1990 forecast.

Table 47--Average U.S. farm fuel prices 1/

Year	Gasoline	Diesel	LP gas
	$/gallon 2/		
1981	1.29	1.16	0.70
1982	1.23	1.11	0.71
1983	1.18	1.00	0.77
1984	1.16	1.00	0.76
1985	1.15	0.97	0.73
1986	0.89	0.71	0.67
1987	0.92	0.71	0.59
1988	0.93	0.73	0.59
1989	1.05	0.76	0.58

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 2/ Bulk delivered.

Energy Expenditures Up In 1989

In 1989, farm energy expenditures on gasoline, diesel fuel, LP gas, electricity, natural gas, and lubricants totaled $8.7 billion, up 22.5 percent from a year earlier (table 48). This rise reflects a 32.6-percent jump in fuel and lubricant expenditures and about a 5.7-percent increase in electricity expenditures. Higher energy prices, fewer abandoned acres (a not uncommon occurrence in 1988 due to the drought), higher yields, and a larger number of acres planted in 1989 over 1988 accounted for these increases. In 1990, a moderate gain in planted acreage and a slight increase in the number of acres irrigated are projected to raise farm energy expenditures 5 percent.

Table 48--Farm energy expenditures

Item	1987	1988	Preliminary 1989	Forecast 1990
		$ billion		
Fuels and lubricants:				
Gasoline	1.37	1.42	1.88	1.97
Diesel	2.13	2.12	2.81	2.95
LP gas	0.38	0.38	0.50	0.53
Other	0.47	0.53	0.71	0.74
Electricity:				
Excluding irrigation	2.03	2.17	2.29	2.37
For irrigation	0.43	0.48	0.51	0.53
Total	6.81	7.10	8.70	9.09
Percent change from preceding year		4.25	22.54	4.60

Farm Machinery

Demand

Expenditures for tractors and other farm machinery rose an estimated $570 million in 1989 to $6.6 billion (table 49). The rise will likely continue in 1990, approaching 1984's $7.2 billion. Machinery sales increased despite higher nominal machinery and equipment loan rates and lower net cash income--factors that would normally dampen demand. Offsetting these factors, farm equity continued to improve in 1989. The decline in the debt-asset ratio reduced foreclosure risks and may have encouraged some farmers to invest in new machinery not purchased during the mid-1980's due to depressed farm incomes. Also, decreased set-aside requirements prompted farmers to divert fewer acres in 1989 than in 1987 and 1988. More planted acres helped boost farm machinery sales.

Land Values Increase

The recovery of land values in 1988 and 1989 may reflect heightened expectations of farm profitability. High values also improve the equity position of farm owners and help in the financing of machinery purchases. Although land values showed a nominal increase of 6 percent from 1988 to 1989, they rose only 1 percent in real terms (inflation adjusted). Values are expected to continue rising in early 1990 at an average rate slightly above 6 percent.

Interest Rates Increase

The real farm machinery and equipment loan rate (inflation adjusted) reached 10 percent in 1989, reversing an annual downward trend from 1984 (table 50) up 28 percent from 1988's rate of 7.8 percent. The nominal rate increased to 12.9 percent.

Government Payments Decrease

Direct Government payments dropped almost 25 percent from 1988 to 1989. Lower Government payments have a mixed effect on farm machinery purchases. The payment reduction can be largely attributed to lower deficiency payments prompted by higher feed and food grain prices stemming from the 1988 drought, which raised farm income. For some farmers, increased Conservation Reserve Program rental payments partially offset lower payments for wheat, corn, and sorghum.

Unit Sales

Increases in new farm machinery unit sales occurred in all categories, reversing previous downward trends in some categories. For example, combine sales rose 52 percent from 1988, according to preliminary estimates. The number of combines sold is forecast to surge another 37 percent in 1990. Large increases in sales of tractors and combines partially reflect recovery from the depressed sales levels of the mid-1980's.

Tractor Sales Up

Sales of tractors in the higher horsepower ranges have increased more than proportionally in this recent recovery. In 1989 four-wheel-drive tractors constituted 7 percent of reported tractor sales, compared with 5 percent in 1988 and 3 percent in 1987. Sales of smaller tractors in the 40- to 99-horsepower range decreased from 64 percent in 1987 to 59 percent in 1989 (table 50).

The forecast for sales of four-wheel-drive tractors--6,000 units for 1990--is 9 percent of all forecast sales. This figure represents a 45-percent gain from 1989 and implies that four-wheel-drive units probably will have a larger proportion of tractor sales than the 1978-80 annual average. Increased sales of larger tractors may be due in part to a trend toward larger farms. The 1987 Census of Agriculture reported a 7-percent decrease in the number of farms since 1982 and an increase in the average farm size to 462 acres from 440 acres in 1982. Larger tractors handle larger implements and can cover more ground per pass. The increased sales of larger tractors suggest that farmers find them more cost-effective than smaller tractors.

Though the sales of farm tractors have been climbing, sales still equal less than one-half of the average number of units sold in 1978-80. Continued increases in net farm income, real estate assets, and farm exports, together with decreases in farm debt and diverted acres, will likely sustain monetary sales. However, unit sales may not soon reach the 1978-80 high's. These were profitable years for U.S. agriculture that afforded farmers the opportunity to step up replacements of machinery and equipment. Fewer, larger farms and the trend toward larger equipment may help preserve the 1978-80 record.

Table 49--Trends in U.S. farm investment expenditures and factors affecting farm investment demand

Item	1984	1985	1986	1987	1988	Preliminary 1989	Forecast 1990
				$ billion			
Capital expenditures:							
Tractors	2.54	1.94	1.51	1.85	2.22	2.4	2.4-2.8
Other farm machinery	4.68	3.65	3.09	3.92	3.81	4.2	4.2-4.6
Total	7.22	5.59	4.60	5.77	6.03	6.6	6.6-7.1
Tractor and machinery repairs	3.8	3.7	3.7	3.9	4.1	4.3	4.2-4.6
Trucks and autos	2.04	1.77	1.71	1.85	2.08	2.1	1.9-2.3
Farm buildings 1/	3.26	2.26	2.14	2.20	2.14	2.7	2.7-3.0
Factors affecting demand:							
Interest expenses	21.1	18.7	16.9	15.5	15.2	15	14-16
Total production expenses	142.7	134.0	122.4	128.0	135.0	141	139-142
Outstanding farm debt 2/ 3/	204	188	167	154	149	145	144-150
Farm real estate assets 2/	694	606	554	626	659	703	735-745
Farm nonreal estate assets 2/	209	191	182	247	269	270	270-280
Agricultural exports 4/	38.0	31.2	26.3	27.9	35.3	39.7	38.0
Net farm income	32.2	32.4	38.0	43.6	42.7	48	44-49
Net cash income	38.7	46.7	51.8	54.5	57.2	53	52-57
Direct Government payments	8.4	7.7	11.8	16.7	14.5	11	8-11
				Million acres			
Diverted acres 5/	27.0	30.7	48.2	76.2	77.6	59.5	na
				Percent			
Real prime rate 6/ 7/	8.3	6.9	5.8	4.5	4.9	8.9	7.4
Nominal farm machinery and equipment loan rate 8/	14.6	13.7	12.2	11.5	11.7	12.9	na
Real farm machinery and equipment loan rate 7/	10.8	10.7	9.4	8.1	7.8	10.0	na
Debt-asset ratio 9/	21.5	22.2	21.4	17.6	16.0	14.9	14-15

na = Not available.

1/ Includes service buildings, structures, and land improvements. 2/ Calculated using nominal dollar balance sheet data, including farm households for December 31 of each year. 3/ Excludes CCC loans. 4/ Fiscal year. 5/ Includes acres idled through commodity programs and acres enrolled in the Conservation Reserve Program. 6/ Monthly average. 7/ Deflated by the GNP Deflator. 8/ Average annual interest rate. From the quarterly sample survey of commercial banks: Agricultural Financial Databook, Board of Governors of the Federal Reserve System. 9/ Outstanding farm debt (including households) divided by the sum of farm (including households) real and nonreal estate asset values.

Source: Economic Indicators of the Farm Sector, National Financial Summary, 1988, Sept. 1989; and other ERS sources.

Table 50--Domestic farm machinery unit sales

Machinery category	Annual average 1978-80	1985	1986	1987	1988	Preliminary 1989	Forecast 1990	Change 88-89	Change 89-90
				Units				Percent	
Tractors:									
Two-wheel-drive--									
40-99 hp	62,818	37,847	30,848	30,718	33,154	34,198	37,000	5	6
100-139 hp	38,650	7,300	5,149	5,084	4,320	5,219	6,000	21	15
Over 139 hp	20,893	10,400	9,313	10,818	11,802	15,396	17,500	30	14
Total over 99 hp	59,543	17,700	14,462	15,902	16,122	20,588	23,500	28	14
Four-wheel-drive	10,276	2,912	2,037	1,653	2,729	4,152	6,000	52	45
Grain and forage harvesting equipment:									
Self-propelled combines	29,834	8,411	7,660	7,172	5,995	9,111	12,500	52	37
Forage harvesters 1/	11,145	2,460	2,164	2,280	2,406	2,803	3,200	17	14
Haying equipment:									
Mower conditions	23,392	11,243	10,898	11,239	11,043	13,153	15,000	19	14

1/ Shear bar type.

Source: Historical data are from the Farm and Industrial Equipment Institution (FIEI). All 1989 and 1990 values are ERS forecasts.

A Short-Run Forecasting Model for Retail Fertilizer Prices

by

Harry L. Vroomen

Abstract: This study combines regression and time series analysis to develop a short-run price forecasting model of retail fertilizer prices. Time series analysis is used to generate forecasted values for the wholesale prices of anhydrous ammonia, phosphoric acid, and potassium chloride. These forecasts are incorporated into regression equations to forecast the retail prices of 14 major fertilizer mixtures and materials. Finally, the retail price forecasts are combined to generate a forecast of the index of fertilizer prices paid by farmers. Results show that this method can perform with reasonable accuracy for short-term forecasting purposes.

Keywords: Fertilizer prices, forecasting, time series analysis, regression.

U.S. fertilizer prices have been highly variable since the mid-1970's and exhibited increased volatility throughout the 1980's. For example, aggregate fertilizer prices, as measured by the index of fertilizer prices paid by farmers (PPI), fell 20 percent from May 1984 to April 1987, but rose nearly 21 percent from April 1987 to April 1989. Prices then changed direction again, falling 7 percent by October 1989. Wholesale fertilizer prices have followed a similar pattern.

This variability complicates the planning process for fertilizer suppliers and users. For example, input manufacturers need to forecast fertilizer prices to plan production levels and decide on contract terms for future delivery. Similarly, farmers need to have some idea of the direction and magnitude of fertilizer price changes to make informed decisions with respect to crop mix and the timing of fertilizer purchases. Consequently, accurate fertilizer price forecasts can foster the efficient operation of the market.

Forecasting Tools

Analysts may base their forecasts on their own beliefs about the market or on mathematical or statistical models. Models used to forecast economic variables such as the price of fertilizer generally fall into two broad classes: those based on explicit behavioral assumptions, and those based on extrapolating observed trends and patterns. In behavioral models, future movements in a variable are predicted by relating a set of explanatory variables in a causal framework. Prices, for example, are typically hypothesized to be determined simultaneously by supply and demand.

The development of a behavioral model of the fertilizer industry to forecast prices would take considerable time and energy, and would have significant data requirements. In addition, insufficient data exists to account for seasonal factors in a behavioral framework. However, elements of extrapolative and behavioral modeling can be combined to take advantage of rich data sources and overcome data gaps. This hybrid modelling procedure allows incorporation of some variables known to influence economic behavior and specification of short-run and seasonal movements in some variables we want to forecast.

In the case of fertilizer, consumption data for specific mixtures and materials are currently published on an annual basis (7). This precludes the estimation of a model that can account for seasonal factors, which are particularly important for fertilizer because demand is greatest at or near planting (6). Furthermore, the consumption data do not become available until 6 months after the fertilizer year (July 1-June 30), limiting its usefulness in formulating short-run forecasts. (Lags in the availability of supply data also exist.)

Fortunately, wholesale price data for selected products are available on a weekly basis with a lag of only a few days (4). This permits the development of time series models to produce forecasts that include the latest market information on prices.

Time series (ARIMA[1]) models are based on the market inertia or observable seasonal patterns in the series under investigation rather than the linkages among economic variables. Leuthold and others found that this stochastic, noncausal framework could be used with greater ease and less cost than behavioral models in forecasting daily hog prices and quantities (3). Such models frequently outperform behavioral models in short-run forecasting. This class of models can also be easily updated, permitting the forecast user to benefit from the latest information available. This study is designed to develop a short-run price forecasting model for 14 major fertilizer mixtures and materials.

1/ Autoregressive-integrated-moving-average.

Price forecasts are generated for the spring, the peak demand season for fertilizer. Time series analysis is conducted to forecast wholesale prices of three selected fertilizer materials. These forecasts are then incorporated into regression equations at the retail level to construct an operational model which can be used to forecast retail fertilizer prices. These retail price forecasts are then combined to generate a forecast of the PPI for fertilizer.

The Model

The model used to develop retail price forecasts for the selected products can be separated into sequential components: (1) ARIMA models for the wholesale price of a representative material for each fertilizer nutrient class (nitrogen, phosphate, and potash); (2) regression models for the retail price of a representative material for each nutrient class which incorporate the wholesale price forecasts generated from the ARIMA models; and (3) regression models to estimate how movements in the retail prices of the representative products in each nutrient class affect the retail prices of other selected fertilizer mixtures and materials. The retail price forecasts are combined to forecast the PPI for fertilizer. The logical relationships between these components are shown in fig. A-1.

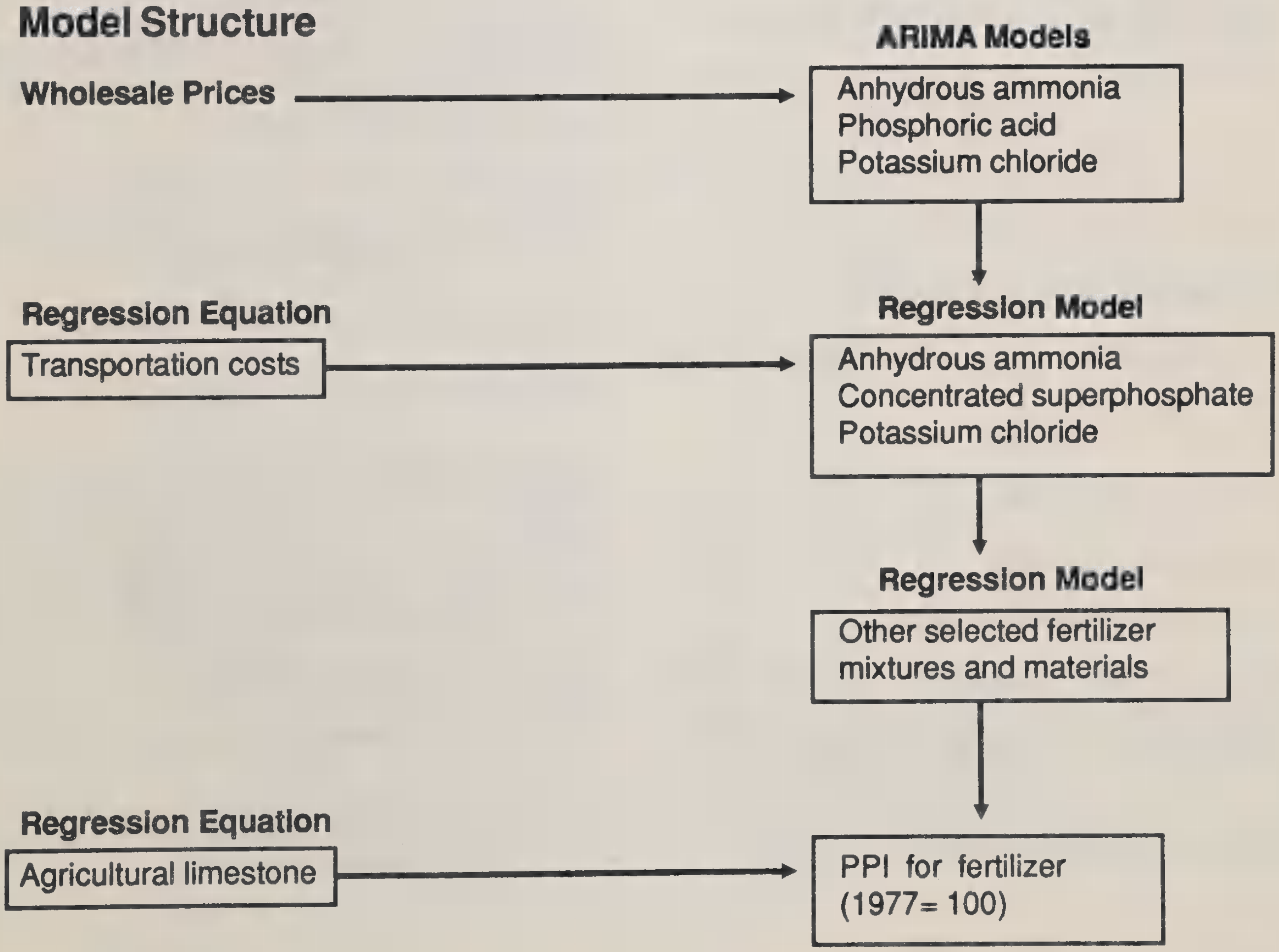
Wholesale Price Models

Monthly ARIMA models are developed for the wholesale prices of the basic materials of the nitrogen, phosphate, and potash fertilizer sectors. These materials, anhydrous ammonia (AA), phosphoric acid (PA), and potassium chloride (PC), each have unique production characteristics and are derived from different natural resources (1). AA, the basic material of the nitrogen industry, is synthesized through a chemical process that combines atmospheric nitrogen with hydrogen (derived from natural gas) and is the source of nearly all nitrogen fertilizer used in the United States. It may be applied directly to the soil or converted into other nitrogen fertilizers, such as ammonium nitrate and nitrogen solutions.

Nearly all phosphate fertilizer is produced by first treating phosphate rock with sulfuric acid to produce PA. The resultant PA is then further processed into various phosphatic fertilizer materials. Potash ore is mined and can be used with less processing or refining than nitrogen or phosphate. It can be directly applied as PC, which accounts for 94 percent of all single-nutrient potash use in the United States, or used in the production of other fertilizer products.

Wholesale prices were selected from the most relevant market for each material (4). F.o.b. prices for AA are determined at New Orleans, U.S. Gulf, near most of the domestic ammonia capacity (8). Similarly, f.o.b. PA prices are deter-

Figure A-1
Model Structure



mined at Central Florida, where most of the PA capacity is located. However, wholesale prices for PC are determined at Saskatchewan, Canada. Canada is the world's largest potash exporter and Canadian imports dominate the U.S. market for PC; imports of PC from Canada typically account for 85 percent of total U.S. potash use, and thus drive domestic potash prices (13). Consequently, the wholesale potash price data used are for coarse potassium chloride (muriate of potash), f.o.b. Saskatchewan.

Retail Prices of Selected Single-Nutrient Materials

While AA, PA, and PC are the basic materials of the fertilizer industry, retail prices are not available for PA. However, prices at the retail level are available for concentrated superphosphate (CS), which is produced by treating phosphate rock with PA. CS is the most popular single-nutrient phosphate material and is also used in the production of other products. Therefore, AA, CS, and PC were selected as the representative materials for the three nutrient classes.

The retail prices of AA, CS, and PC would reflect price changes at the wholesale level if retailers followed a markup pricing scheme. However, retail prices should also be affected by changes in marketing costs not reflected in f.o.b. prices. Transportation costs represent a significant share of the final price a farmer pays for fertilizer, and rail is the predominant method of transporting fertilizer in the United States (1). Marketing costs are thus represented by the cost of rail transportation.

The retail price models for AA, CS, and PC are specified as:

$RP_i = f(WP_j, TRANS, e)$ [1]

where:

RP = retail price of fertilizer material *i*

WP = wholesale price of fertilizer material *j*

TRANS = total rail freight rate index (Dec. 1984=100) (12)

i = AA, CS, or PC, respectively

j = AA, PA, or PC, respectively

e = a stochastic disturbance term.

Retail Prices of Other Fertilizer Products

In addition to AA, CS, and PC, equations are specified for the following 11 fertilizer mixtures and materials: 0-20-20, 5-10-10, 5-10-15, 6-24-24, 8-32-16, 10-10-10, 10-20-10, 16-20-0, 18-46-0, ammonium nitrate, and nitrogen solutions (32 percent). These products were selected because they are among the leading fertilizer products used in the United States and because they complete the list of products included in USDA's PPI for fertilizer (9).

Many different fertilizer products are produced from AA, PA, CS, and PC. Consequently, retail prices of single-nutrient fertilizer materials within a nutrient class are highly correlated. Similarly, the prices of fertilizer mixtures (for example, 6-24-24) are highly correlated with price movements of the nutrients contained in those mixtures. Since retail prices are not available for PA, the model for the 11 additional fertilizer products was specified as:

$RP_i = f(RP_j, e)$ [2]

where:

RP = the retail price of fertilizer product *i* or *j*

i = the 11 additional selected fertilizer products

j = AA, CS, and PC[2]

e = a stochastic disturbance term.

Estimated Models

Time Series Results for Wholesale Prices

The value of the wholesale price series for each selected fertilizer material was modeled as a function of both lagged random disturbances (moving average) and its own past values (autoregressive) as well as current disturbance terms. The ARIMA models were developed through the iterative technique of identification, estimation, and diagnostic checking popularized by Box and Jenkins (2).

Monthly ARIMA models for AA and PA were fit using the entire data series for February 1977-October 1989. Appropriate models for these products were identified as:

$(1-B)(1-B^{12})AA_t=(1-\theta_{12}B^{12})(1-\varphi_1B-\varphi_5B^5)e_t$, and

$(1-B)(1-B^{12})PA_t=(1-\theta_{24}B^{24})(1-\varphi_1B-\varphi_3B^3-\varphi_{12}B^{12})e_t$.

The ARIMA model for PC was modified to account for the effects of an antidumping case against Canadian potash producers. Farmers faced record potash prices during spring 1988 as a result of a successful U.S. antidumping case against Canadian potash producers. On August 20, 1987, the U.S. Department of Commerce (DOC) announced a preliminary finding that Canadian potash had been dumped in the United States at margins ranging from 9.1 to 85.2 percent of fair market value. Thereafter, the posting of bonds or cash

2/ When the price of a single-nutrient material or mixture containing only 1 or 2 nutrients is estimated, only the price of the product(s) representing the nutrient(s) contained in that material is included.

deposits was required on all potash brought to the United States from Canada, significantly raising prices.

In January 1988, the antidumping case was suspended when eight Canadian potash producers and DOC signed an agreement prohibiting Canadian producers from dumping potash in the United States at more than 15 percent of the preliminary margins set for each producer by DOC in August. Prices remained significantly above their pre-intervention levels following the agreement (12). To account for the effect of the trade case on wholesale potash prices, the ARIMA model for PC was modified by the inclusion of an impact parameter, I_t. The appropriate model for PC was identified as:

$$(1-B)(1-B^{12})PC_t = w_0 I_t + (1-\theta_{12}B^{12})(1-\varphi_2 B^2-\varphi_3 B^3-\varphi_9 B^9-\varphi_{15} B^{15})e_t$$

Table A-1 shows maximum-likelihood estimates and associated diagnostic statistics for each of the time series models. The estimates of the moving average (θ) and autoregressive (φ) parameters are all statistically significant and lie within the bounds of invertibility. Respective Q-statistics for each model are not significant at the 95-percent level, indicating that there is no observable structure remaining in the residuals (the residuals are distributed with zero mean and covariance, with a finite and constant variance). The impact coefficient for PC is significant at the 99-percent confidence level, indicating (as expected) that the trade case with Canada significantly raised f.o.b. potash prices.

Regression Results for AA, CS, and PC

From 1977 to 1985, retail fertilizer prices were reported for March, May, October, and December. Since 1986, however, retail prices have only been available for April and October (9, 10, 14). To form a continuous data set, March and May retail prices were averaged to construct an April price for years preceding 1986, while reported prices for April were used for the subsequent years. Consequently, the retail price equations in [1] were estimated with biannual data (April and October) for 1977-89.

Visual inspection of the PC data indicated that only part of the wholesale price increase resulting from the trade case against Canada may have been passed on to the retail level. Consequently, the equation for PC was modified to test whether the wholesale-retail price relationship was altered by the trade case. This modification was accomplished by the inclusion of a dummy variable, D1, which was set to equal 0 before October 1987 and 1 otherwise.

Preliminary results indicated that the disturbances of the CS equation followed a first-order autoregressive process. In addition, first-order autocorrelation could not be ruled out for the AA equation. All equations in [1] were thus estimated with a maximum-likelihood autoregressive technique (5). Autoregressive techniques use the time series part of a

Table A-1--Estimated time series models for wholesale prices of anhydrous ammonia, phosphoric acid, and potassium chloride

Parameter	Estimated coefficients	Standard error	t-statistic	Q-statistic 1/
		Measure		
Anhydrous ammonia:				9.74
θ12	0.7529	0.0894	8.42	
ϕ1	0.5413	0.0677	7.99	
ϕ5	-0.1655	0.0698	2.37	
Phosphoric acid:				24.62
θ24	0.6728	0.1418	4.75	
ϕ1	0.2040	0.0646	3.16	
ϕ3	-0.1531	0.0636	2.41	
ϕ12	-0.5979	0.0948	6.31	
Potassium chloride:				16.61
θ12	0.8050	0.0832	9.68	
ϕ2	-0.1290	0.0775	-1.66	
ϕ3	-0.1296	0.0772	-1.68	
ϕ9	0.1736	0.0783	2.22	
ϕ15	0.2449	0.0777	3.15	
W_0	28.2838	3.4358	8.23	

1/ Value based on 24 residual autocorrelations.

Table A-2--Estimated retail price equations for anhydrous ammonia, concentrated superphosphate, and potassium chloride

Dependent variable	Explanatory variables 1/ Intercept	i-f.o.b.	TRANS	D1	Estimated autoregressive parameter ($\hat{\rho}$)	Adjusted R^2
Anhydrous ammonia	54.516	0.818 (9.05)	0.698 (4.12)		0.178 (0.84)	0.863
Concentrated superphosphate	12.904	56.560 (9.27)	0.394 (2.15)		0.554 (2.98)	0.945
Potassium chloride	7.646	1.614 (11.49)	0.255 (3.03)	-18.441 (4.03)	-0.103 (0.47)	0.919

1/ Prescript i = anhydrous ammonia in the first equation, phosphoric acid in the second equation, and potassium chloride in the last equation. TRANS = the total rail freight rate index (December 1984=100). D1 is a dummy variable representing the trade case against Canadian potash producers. Numbers in parentheses are t-statistics.

model as well as the systematic part in generating predicted values and so are useful forecasting tools.

Table A-2 shows the estimated coefficients and t-statistics for each of the retail price equations. The R^2's indicate that the explanatory variables explain most of the variation in the retail prices of AA, CS, and PC. All coefficients have the hypothesized signs and are statistically significant at the 5-percent level. The coefficient of D1 indicates that only part of the f.o.b. price increase for PC resulting from the trade case was passed on to the retail level.

Regression Results for Other Fertilizer Products

Retail price equations in [2] were estimated with data for September 1967-October 1989. This period was determined by data availability; retail price data for nitrogen solutions (32 percent) were not reported before September 1967 (10). However, because of changes in the frequency of data reporting, retail prices for these equations were for April and September in 1965-76, a March-May average and October in 1977-85, and April and October in 1986-89. Preliminary results indicated that the disturbances of all equations in [2] followed a first-order autoregressive process. Consequently, these equations were also estimated with a maximum-likelihood autoregressive technique.

Multicollinearity is a potential problem when more than one nutrient price is included on the right-hand side of an equation, because the prices of AA, CS, and PC are correlated, making it difficult to separate out the effects of each material. However, the equations in [2] are estimated solely for their predictive ability and not for the reliable estimation of the parameters. Table A-3 shows the coefficients for each of the 11 retail price equations. R^2's suggest that all 11 equations exhibit significant predictive power.

Developing Model Forecasts

Fertilizer price forecasts are generated from the estimated equations using the following procedure. First, the ARIMA models for AA, PA, and PC are used to forecast f.o.b. prices through April. Next, these forecasts are incorporated into the equations in [1] to generate retail price forecasts for AA, CS, and PC for April. The system of equations in [1] also requires forecasts of the total rail freight rate index (TRANS). Forecasts for TRANS were generated from:

$$TRANS_t = 6.89 + 0.944 * TRANS_{t-1}$$
$$(42.56)$$

where:
t = April and October 1977-89.

Retail price forecasts for AA, CS, and PC are then used to generate retail price forecasts for other major fertilizer mixtures and materials from [2]. Finally, the retail price forecasts generated are combined to construct a forecast of the PPI for fertilizer. In addition to the 14 retail prices forecast, the fertilizer PPI includes the price of agricultural limestone (AL) (9). Forecasts for AL were generated from:

$$AL_t = 1.68 + 0.901 * AL_{t-1}$$
$$(24.27)$$

where:
t = April and October 1977-89

Although the fit for the equations in tables A-1 through A-3 appears adequate, the usefulness of a forecasting model lies in its predictive power. To evaluate forecasting performance, the full model was required to make a set of out-of-sample forecasts, which were then compared with actual values to determine the magnitude and direction of forecast error.

Table A-3--Estimated retail fertilizer price equations for selected mixtures and materials

Dependent variable	Explanatory variables 1/ Intercept	AA	CS	PC	Estimated autoregressive parameter ($\hat{\rho}$)	Adjusted R^2
0-20-20	31.820		0.405 (8.91)	0.282 (3.09)	0.967 (21.98)	0.976
5-10-10	45.161	0.031 (0.67)	0.243 (3.39)	0.141 (1.36)	0.985 (30.70)	0.974
5-10-15	36.590	0.045 (0.96)	0.264 (3.65)	0.176 (1.67)	0.987 (36.46)	0.955
6-24-24	8.878	0.139 (5.56)	0.434 (9.42)	0.481 (9.85)	0.286 (1.88)	0.997
8-32-16	13.144	0.139 (4.69)	0.625 (11.75)	0.291 (5.07)	0.464 (3.28)	0.997
10-10-10	53.044	0.091 (1.86)	0.273 (3.61)	0.063 (0.57)	0.986 (28.58)	0.975
10-20-10	38.769	0.068 (0.87)	0.459 (3.76)	0.186 (1.05)	0.948 (19.78)	0.967
16-20-0	74.000	0.174 (2.13)	0.360 (3.10)		0.984 (30.33)	0.943
18-46-0	4.808	0.102 (2.26)	1.037 (17.34)		0.853 (7.57)	0.992
Ammonium nitrate	54.276	0.490 (11.84)			0.971 (19.98)	0.954
Nitrogen solutions (32%)	50.841	0.425 (8.06)			0.911 (12.36)	0.939

1/ AA = anhydrous ammonia, CS = concentrated superphosphate, and PC = potassium chloride. Numbers in parentheses are t-statistics.

Out-of-sample forecasts were generated 6 months ahead at a time. This procedure was repeated twice for each set of equations as the time period for each was sequentially updated. That is, the models were estimated based on data through October 1987 and used to forecast prices for April 1988. Prices for April 1989 were forecast with models estimated through October 1988. Sequentially updated forecasting incorporates new information in parameter estimates and is the efficient way to use this model because it is easily updated. However, the model can also be used by updating only the ARIMA models.

Table A-4 lists actual and forecasted values for all products considered and the PPI for fertilizer. Overall, the predictive performance of the model appears satisfactory. Mean absolute percent errors for April 1988 and 1989 indicate that, on average, the retail price forecasts missed their mark by less than 3 percent; only 2 of the 28 retail price forecasts missed their actual value by more than 7 percent. Forecasts of the fertilizer PPI missed their mark by less than 2 and 1 percent, respectively, in 1988 and 1989. The accuracy of the fertilizer PPI forecasts stems partly from the fact that positive forecast errors cancel out negative forecast errors in the index construction. Nevertheless, the model does provide an accurate forecast of the direction and magnitude of aggregate fertilizer prices, making it a useful forecasting model.

Forecasts for Spring 1990

Retail fertilizer price forecasts for spring 1990 were generated from the estimated models reported in tables A-2 and A-3. However, to include the latest market information on wholesale fertilizer prices, the ARIMA models were reestimated with data through December 1989. They were then used to generate price forecasts through April 1990, which were in turn used in the retail price equations in [2]. Table A-5 contains the April 1990 retail price forecasts generated by this procedure.

These forecasts indicate that, overall, April 1990 retail fertilizer prices will rise by 4 percent from October 1989, but will fall 4 percent short of their year-earlier levels. Nitrogen

Table A-4--Actual and forecast retail fertilizer prices, April 1988 and 1989

	April 1988			April 1989		
	Forecast	Actual	Error	Forecast	Actual	Error
PPI-fertilizer (1977=100)	130	132	-1.5	142	141	0.7
Product 1/:	-- $/ton --		Percent	-- $/ton --		Percent
AA	204	208	-1.9	215	224	-4.0
CS	216	222	-2.7	235	229	2.6
PC	145	157	-7.6	160	163	-1.8
0-20-20	171	182	-6.0	186	182	2.2
5-10-10	138	138	0.0	147	143	2.8
5-10-15	152	150	1.3	158	155	1.9
6-24-24	199	208	-4.3	218	217	0.5
8-32-16	216	223	-3.1	236	232	1.7
10-10-10	150	151	-0.7	164	163	0.6
10-20-10	180	188	-4.3	197	190	3.7
16-20-0	217	217	0.0	225	226	-0.4
18-46-0	247	251	-1.6	265	256	3.5
AN	165	166	-0.6	181	189	-4.2
NS	129	139	-7.2	169	159	6.3
Mean absolute percent error:			2.9			2.6

1/ AA = anhydrous ammonia; CS = concentrated superphosphate; PC = potassium chloride; AN = ammonium nitrate; NS = nitrogen solutions (32 %).

Table A-5--Actual and forecast retail fertilizer prices, April and October 1989 and April 1990

	April 1990	Actual 1989 prices		Change from 1989	
	Forecast	October	April	October	April
PPI-fertilizer (1977=100)	136	131	141	4	-4
Product 1/:	-------- $/ton --------			Percent	
AA	200	180	224	11	-11
CS	213	204	229	4	-7
PC	150	153	163	-2	-8
0-20-20	175	173	182	1	-4
5-10-10	148	146	143	1	3
5-10-15	152	150	155	1	-2
6-24-24	201	196	217	3	-7
8-32-16	218	211	232	3	-6
10-10-10	166	162	163	2	2
10-20-10	190	186	190	2	0
16-20-0	227	221	226	3	0
18-46-0	232	218	256	6	-9
AN	189	180	189	5	0
NS	165	159	159	4	4

1/ AA = anhydrous ammonia; CS = concentrated superphosphate; PC = potassium chloride; AN = ammonium nitrate; NS = nitrogen solutions (32 %).

prices are forecast to increase the most, with the retail price of AA rising by 11 percent from October. However, even with this increase AA prices are expected to remain below April 1989 levels. Phosphate prices are forecast to follow a similar pattern as the prices of CS and 18-46-0 increase from fall 1989, but also fall short of their year-earlier levels. However, the price of PC is forecast to drop to $150 per ton, down from both April and October 1989. Retail prices of other mixtures and materials are more mixed, with some forecast to increase over April 1989, some expected to decline, and others expected to show no change.

It should be noted that the accuracy of these forecasts depends heavily on the underlying structure estimated by the coefficients of the ARIMA and regression models. With a continuation of the embedded time patterns estimated by the ARIMA models and the wholesale-retail and retail-retail price relationships estimated by the regression equations, forecasts should be relatively accurate. However, if the relationships estimated change in any significant way, the forecasts may miss their mark.

Conclusions

Accurate short-run fertilizer price forecasts are useful to both fertilizer users and producers. Producers need accurate price forecasts to make efficient production plans; such forecasts could also aid in improving managerial decisionmaking on the farm. The pricing model outlined in this article provides a tool that can be used to forecast spring prices of selected fertilizer products with reasonable accuracy. Out-of-sample forecasts indicate that the model performs particularly well as an indicator of aggregate fertilizer price changes.

The model uses a combination of time series (ARIMA) and regression analysis and, once operational, it can be updated easily. ARIMA models are estimated and used to forecast wholesale prices for AA, PA, and PC. The wholesale price forecasts are incorporated into regression equations to generate retail price forecasts for AA, CS, and PC. Forecasts of these products are in turn incorporated into regression equations of 11 other major fertilizer mixtures and materials. Finally, the 14 retail fertilizer price forecasts are combined to construct a forecast of aggregate fertilizer prices (PPI).

Estimated results suggest that aggregate retail fertilizer prices will rise by 4 percent from October 1989 to April 1990, but will not match those of a year earlier. The retail price of AA will show the greatest increase over October, but may fall 11 percent short of its April 1989 level. Similarly, the retail prices of CS and 18-46-0 are forecast to rise from October 1989, but also will not reach year-earlier levels. The price of PC is forecast at $150 per ton, down from both April and October 1989. Retail prices of other mixtures and materials are more mixed.

References

1. Andrilenas, Paul, and Harry Vroomen. Fertilizer, *Seven Farm Input Industries*, Ag. Econ. Report, forthcoming. ERS, USDA.

2. Box, G.E.P., and G.M. Jenkins. "Time Series Analysis, Forecasting and Control." Holden-Day, Inc., San Francisco, CA. 1970.

3. Leuthold, R.M., and others. "Forecasting Daily Hog Prices and Quantities: A Study of Alternative Forecasting Techniques. *Journal of the American Statistical Association* Vol. 65 (1970): 90-107.

4. McGraw-Hill, Inc. *Green Markets: Fertilizer Market Intelligence Weekly* , December 25, 1989, and earlier issues.

5. SAS Institute Inc. "SAS/ETS User's Guide," fifth edition. Cary, NC. 1984.

6. Taylor, Harold, and Harry Vroomen. "Timing of Fertilizer Applications," *Agricultural Resources: Inputs Situation and Outlook,* ERS, USDA, August 1989.

7. Tennessee Valley Authority, Economics and Marketing Staff. *Commercial Fertilizers.* Muscle Shoals, AL. December 1988 and earlier issues.

8. ______________. "North American Fertilizer Capacity Data." Muscle Shoals, AL. July 1989.

9. U.S. Department of Agriculture, National Agricultural Statistics Service. "Agricultural Prices," Washington, DC., April and October 1989.

10. ______________. Agricultural Prices, Washington, DC. Various annual summaries. 1967-88.

11. U.S. Department of Labor, Bureau of Labor Statistics.

12. Vroomen, Harry. "Future Potash Prices: Higher, But Less Volatile," *Agricultural Outlook,* AO-144. ERS, USDA. August 1988.

13. ______________. *Fertilizer Trade Statistics, 1970-88,* Statistical Bulletin No. 782. ERS, USDA. June 1989.

14. ______________. *Fertilizer Use and Price Statistics, 1960-88,* Statistical Bulletin No. 780. ERS, USDA. June 1989.

Soil Tests and 1989 Fertilizer Application Rates

by

Matt Spilker, Stan Daberkow, and Harold Taylor

Abstract: Survey results show that soil tests were conducted on a significant portion of crop acres throughout the major corn, soybean, wheat, cotton, and rice producing States. Considerable variations in testing frequency were observed by State, crop, and nutrient. The difference between fertilizer application rates on soil tested and untested acres also varied widely by State and crop. Nitrogen application rates were higher and nitrogen testing occurred more frequently on irrigated than nonirrigated cornland. Further empirical research is needed to determine soil testing's impact on nutrient application rates.

Keywords: Soil testing, nutrient application, uncertainty.

Soil testing has long been advocated as a means of potentially increasing the profitability of agricultural production. The producer may use information from soil tests and other sources to determine the optimal amounts of fertilizer to apply.

Soil testing may also impact broader objectives of society. Evidence now suggests that agriculture may be a significant source of ground and surface water contamination (2,3). Conservation management strategies have been employed to inhibit soil loss and consequently slow surface water contamination. In addition, crop rotations have been suggested as a way to reduce dependence on chemical fertilizer; such rotations could reduce the potential for nutrient leaching and groundwater contamination, provided the soil has a lower nitrate level. Similarly, soil testing has been advanced as a management tool, since the additional information it provides may prompt producers to revise decisions about fertilizer use. Soil testing, therefore, may indirectly influence surface and ground water contamination.

Extent of Soil Testing

The 1989 Cropping Practices Survey shows that the frequency of soil testing varied widely by type of test, State, year, and crop (table B-1). For nearly all States and crops surveyed, soil testing was less prevalent for nitrogen (N) than for phosphorus and potassium (P and K). This was especially true for corn and soybeans, but much less so for spring and durum wheat. Some parts of the Corn Belt, particularly the eastern area, do not have a reliable N test available.

Survey results for nitrogen tests on soybean acres are not reported because few soil test laboratories actually perform such a test for soybeans. Also, the percent of acres tested for nitrogen on the other crops should be interpreted as an upper limit of the acres on which nitrogen testing was used as a management tool. In some cases soil testing laboratories give a nitrogen recommendation based solely on yield goal and do not actually perform a test for residual nitrogen.

The 1989 Cropping Practices Survey was constructed to determine whether a soil test was conducted either in 1987 or between January 1988 and spring 1989. The difference in the lengths of the periods may influence the statistical comparison. Also, the 1988 drought may have increased nutrient carryover into 1989 and encouraged more or less testing than normal. For all crops and nearly all States, more P and K tests were conducted in the 1988/89 period than in the 1987 period. For most cropland, the portion of acres P and K tested increased 3-9 percent. In contrast, 16 percent of winter wheat cropland was tested for P and K in both periods. The amount of acreage tested for nitrogen increased 2-7 percent between the two periods, with durum wheat, cotton, and corn cropland rising the most.

P and K testing was conducted on about one-third of the acres planted to spring wheat and corn in 1989. Among all surveyed crops, P and K testing was lowest on winter wheat (16 percent) and rice (20 percent). N testing was most prevalent on spring wheat acres (30 percent), followed by durum wheat, cotton, and corn. Winter wheat, soybean, and rice acres tended to have the lowest number of acres N-tested. For most crops, the higher the nutrient application rate, the greater the share of acres tested. However, the lack of an adequate N-test for many parts of the country may have distorted this relationship, especially for corn.

The extent of soil testing for all three nutrients varied widely by State or region. For example, corn acreage in Iowa, Minnesota, and irrigated land in Nebraska was most intensively tested, while the soils in Illinois, Wisconsin and the nonirrigated acres in Nebraska were tested the least. Tested soybean acreage was very high in Georgia (68 percent), where soil tests are offered at no charge, followed by Iowa and Minnesota. In 1988/89, soybean land in Arkansas, Illinois, Louisiana, Mississippi, and Missouri were tested the least. Louisiana and Mississippi had the largest share of cotton acres tested; Texas had the least. Winter wheat acreage was most widely tested in Idaho and Oregon (over 30 percent)

Table B-1--Proportion of land soil tested for nutrient levels, major field crops, 1989

Crop/State	Acres planted	Phosphate or potash 1987	Phosphate or potash 1988-89	Nitrogen 1987	Nitrogen 1988-89
	Thousand	Percent			
Corn:					
Illinois	10,900	23	25	4	6
Indiana	5,500	34	34	20	18
Iowa	12,700	28	42	12	23
Michigan	2,300	22	35	8	13
Minnesota	6,200	34	37	26	28
Missouri	2,400	19	27	8	19
Nebraska	7,500	29	42	26	37
Non-irrigated	2,300	18	20	15	15
Irrigated	5,200	34	52	30	47
Ohio	3,400	29	34	12	18
South Dakota	3,400	14	22	13	20
Wisconsin	3,600	17	16	6	9
Area	57,900	26	33	13	20
Cotton:					
Arizona	460	26	26	26	21
Arkansas	590	30	39	19	29
California	1,069	23	39	22	35
Louisiana	650	29	54	25	43
Mississippi	1,100	25	48	13	36
Texas	4,575	15	17	13	13
Area	8,444	20	29	16	23
Winter wheat: 1/					
Arkansas	1,350	15	17	11	15
California	570	10	10	8	9
Colorado	2,100	9	9	5	8
Idaho	810	29	31	29	31
Illinois	1,800	19	9	3	2
Indiana	880	30	19	20	10
Kansas	9,600	16	16	13	13
Missouri	1,850	21	24	15	21
Montana	1,700	13	15	11	13
Nebraska	2,050	4	7	*	*
Ohio	1,200	31	25	15	13
Oklahoma	5,700	16	18	16	18
Oregon	800	16	37	16	37
Texas	3,000	10	5	9	5
Washington	1,300	20	25	20	25
Area	34,710	16	16	10	10
Spring wheat:					
Idaho	580	31	38	29	38
Minnesota	2,600	52	59	40	50
Montana	3,500	10	19	10	16
North Dakota	7,700	31	35	31	35
South Dakota	2,200	15	10	15	10
Area	16,580	28	32	26	30
Durum wheat:					
North Dakota	3,000	14	26	14	26
Soybeans:					
Northern--					
Illinois	8,800	23	17	2/	
Indiana	4,600	23	31		
Iowa	8,300	25	36		
Minnesota	5,050	39	35		
Missouri	4,400	9	17		
Nebraska	2,600	20	21		
Ohio	4,000	28	33		
Region	37,750	25	27		
Southern--					
Arkansas	3,500	17	14		
Georgia	1,200	51	68		
Kentucky	1,200	15	23		
Louisiana	1,950	14	11		
Mississippi	2,500	10	17		
North Carolina	1,550	24	31		
Tennessee	1,480	15	22		
Region	13,380	19	23		
Area	51,130	23	26		
Rice:					
Arkansas	1,150	17	20	9	14
California	415	20	25	14	17
Louisiana	520	9	14	4	11
Area	2,085	15	20	9	14

* = Less than 1 percent.

1/ Harvested acres. 2/ Not reported because few soil testing laboratories actually perform a nitrogen test for soybeans.

but totaled less than 10 percent in Texas, Nebraska, Illinois, California, and Colorado. Minnesota reported the most extensive testing of spring wheat land (over 50 percent), while Montana and South Dakota reported the least.

Although some of these State differences can be attributed to the lack of soil testing technology available to predict nutrient availability to the crop, the availability of State or university testing labs and testing costs may also have played a part. For example, only private testing labs operate in Illinois, California, Montana, and Washington.

Comparisons of soil testing within selected States for different crops reveals several distinct patterns. For example, when cotton and soybeans, or cotton and winter wheat, were surveyed within the same State, a higher share of cotton acres was tested than soybean or winter wheat acres (as in Arkansas, Louisiana, Mississippi, Texas, and California). This pattern may reflect the more intensive fertilizer use on cotton than on soybeans or winter wheat. In Minnesota, Ohio, and Iowa, the share of soybean acres tested approximated that of corn, even though P and K application rates were higher on corn than soybeans.

Application rates varied between those fields that were tested and those that weren't (tables B-2 and B-3). For many crops the rates were similar for the two groups (such as corn, winter wheat, soybeans, and rice). Nitrogen use on spring wheat and nitrogen and potash use on cotton were higher for those fields tested in 1988/89. Among such corn States as Illinois, Michigan, Minnesota, and Missouri, nitrogen application rates differed by more than 10 pounds between fields with and without nitrogen tests. However, these differences must be interpreted cautiously because a number of production factors, some of which may be correlated with soil-testing, influence fertilizer application rates. In addition, sampling variation may account for the differences.

Limitations of the Statistical Analysis

Fertilization Decisionmaking

The soil testing process has several aspects. First, a producer must decide whether to test. Perrin links the issues of soil testing and additional information: "[the] value measured [of soil testing] is compared with the alternative of knowing nothing about the piece of land. But farmers have a great deal of information about their land, and the value of this information may on the average be very close to that of the soil test information. If so, the net value of the soil test information would be small" (5, p.60). Whether an individual producer will use soil testing as a management tool remains unclear. If the test's net value is lower than its cost--as would be the case if adequate knowledge of the land already exists--the producer will not test. Furthermore, if producers decide to test, and the test results support the

Table B-2--Plant nutrient application rates per acre for 1989 wheat, soybean, cotton, and rice land with and without a soil test

Crop 1/	Nitrogen	Phosphate	Potash
		Lbs./acre 2/	
Winter wheat:			
With test	74	43	65
Without test	68	41	54
Spring wheat:			
With test	60	33	25
Without test	46	29	23
Durum wheat:			
With test	34	29	id
Without test	32	25	id
Soybeans:			
With test	19	48	74
Without test	17	45	74
Cotton:			
With test	101	47	49
Without test	76	40	34
Rice:			
With test	131	50	52
Without test	124	43	43

id = Insufficient data.

1/ For a listing of crops by State, see Table B-1.
2/ Only fields that received fertilizer were used to calculate application rates.

Table B-3--Plant nutrient application rates per acre for 1989 corn land with and without a soil test

State	Nitrogen	Phosphate	Potash
		Lbs./acre 1/	
Illinois:			
With test	181	80	107
Without test	159	73	100
Indiana:			
With test	128	75	108
Without test	134	80	110
Iowa:			
With test	132	60	74
Without test	127	55	66
Michigan:			
With test	101	48	102
Without test	113	54	106
Minnesota:			
With test	103	51	65
Without test	120	48	62
Missouri:			
With test	148	62	83
Without test	137	57	68
Nebraska:			
Nonirrigated--			
With test	102	30	27
Without test	97	38	13
Irrigated--			
With test	164	37	24
Without test	167	36	27
Ohio:			
With test	142	69	112
Without test	143	73	96
South Dakota:			
With test	76	42	29
Without test	67	31	21
Wisconsin:			
With test	96	51	75
Without test	86	56	72
Area:			
With test	132	59	81
Without test	131	60	81

1/ Only fields that received fertilizer were used to calculate application rates.

producer's knowledge, the testing procedure may have little observable impact on that producer's fertilizer use.

The net effect of soil testing on fertilizer use must also be considered. Although the test may have little observable impact on fertilizer use, producers may make revisions, applying more or less than they intended before they received the test results. This revision may be separated into two individual effects, even though the observed revision will be impacted by both simultaneously. The first effect is the producers' re-evaluation of the soil's nitrogen content; that is, the expected value of fertilizer present in the soil is revised. The second effect relates to the uncertainty surrounding the nutrients the soil provides. For example, a producer, before receiving the test results, may believe 100 pounds of nitrogen are present in one acre of soil. The soil test result may indicate this is indeed the case; however, the level of uncertainty surrounding the expected value may have changed. The producer, after receiving information consistent with prior belief, may then be more certain about how much nitrogen is actually available in the soil.

Feder demonstrated that uncertainty will impact the optimal level of pesticide use. The direction of impact, however, depends upon the physical relationships between input, output, and variable elements of the production process. If similar relationships exist in the fertilization process, the uncertainty concerning nutrient availability may be altered, and the producer may change the fertilizer application rate accordingly, simply due to changes in the level of uncertainty.

Irrigation, Soil Testing, and Nitrogen Application Rates

In addition to data on fertilizer application rates and soil testing, information about other production factors may be needed to determine soil testing's impact on application rates. Irrigation, for example, is widely used in certain areas of the Corn Belt; in these areas, the marginal productivity of a given unit of nitrogen increases, provided that there is complementarity between applied water and applied nitrogen. Therefore, higher nitrogen levels are anticipated. An important question arises: Will the introduction of irrigation also increase the marginal productivity of soil testing? Although research literature has not addressed the issue, relationships observed in sample data may be analyzed.

The statistical comparison of irrigated and nonirrigated cornland supports theoretical expectations of nitrogen application levels (table B-4). The data also show that irrigated cornland was tested more frequently than nonirrigated cornland. Several hypotheses to explain the latter relationship may be offered. First, the marginal productivity of testing may be greater on irrigated ground, since it receives more nitrogen than nonirrigated ground. Consequently, producers' revisions may be greater on irrigated ground than nonirrigated ground. In other words, the soil test may be more valuable

Table B-4--Nitrogen application rates and soil testing on irrigated and nonirrigated corn, 1989

Item	Irrigated	Nonirrigated
For all corn acres:		
Lbs. of nitrogen per acre 1/	157	2/ 127
Percent of acres tested for soil nitrogen	40	2/ 18

1/ Only fields that received fertilizer were used to calculate application rates. 2/ Significant difference between irrigated and nonirrigated means at the 99% confidence level.

to producers who irrigate. Another plausible hypothesis is that government agencies may be providing incentives for soil testing to producers who irrigate, particularly in areas where groundwater contamination has become a public policy issue.

Regardless of the reason for the observed relationship, the correlation between soil testing, nitrogen application rates, and irrigation may affect testing's impact on nutrient application rates. Other production factors may also be correlated with both the presence of soil testing and nutrient application rates. An understanding of any such correlation may be essential to extensive empirical research.

Conclusion

Although the data suggest that soil testing is conducted on a significant portion of acres nationwide, and fertilizer application rates differ on tested and untested acres, they do not indicate whether testing significantly affects fertilizer application rates. It is clear, however, that nitrogen application rates on tested and untested corn acres do not differ significantly. Additionally, the correlation between nitrogen testing, irrigation, and nitrogen application rates may be biasing the differences observed between nutrient application rates on tested versus untested acres. Therefore, the individual impact of testing on nutrient application rates cannot be discovered by simply examining the respective means.

Further research is needed to determine whether soil testing affects nutrient application rates and ultimately how such testing impacts agricultural production and society. A more complete understanding of testing's relationship with other factors of production is needed. Once this relationship is more completely understood, the new information may be combined with existing information to determine testing's net impact on ground and surface water contamination. Finally, testing's net impact on the profitability of agricultural production and on ground and surface water contamination will together determine testing's impact on society.

References

1. Feder, G. "Pesticides, Information, and Pest Management under Uncertainty." *Amer. J. Agr. Econ.* 61 (1979): 97-103.

2. Nielsen E., and L. Lee. "The Magnitude and Costs of Groundwater Contamination From Agricultural Chemicals: A National Perspective." *Agr. Econ. report* 576, ERS-USDA, October 1987.

3. Office of Technology Assessment. *Protecting the Nation's Groundwater From Contamination.* Washington, DC, 1984.

4. *PCCARP*. Iowa State University. Ames, IA. December 1986.

5. Perrin, R. K. "The Value of Information and the Value of Theoretical Models in Crop Response Research." *Amer. J. Agr. Econ.* 58 (1976): 54-61.

Appendix table 1--U.S. fertilizer imports: Declared value of selected materials

Material	Fertilizer year 1987/88	Fertilizer year 1988/89	July - October 1988	July - October 1989
	$ million			
Nitrogen:				
Anhydrous ammonia	252	364	99	73
Aqua ammonia	na	na	na	2
Urea	192	252	45	52
Ammonium nitrate	19	38	5	12
Ammonium sulfate	19	24	5	7
Sodium nitrate	12	16	5	3
Calcium nitrate	16	11	5	2
Nitrogen solutions	35	50	10	5
Other	11	12	7	2
Total 1/	556	767	181	158
Phosphate:				
Ammonium phosphates	20	12	5	1
Crude phosphates	21	32	10	6
Phosphoric acid	#	#	#	#
Normal and triple superphosphate	20	#	#	#
Other	#	1	#	#
Total 1/	61	45	15	7
Potash:				
Potassium chloride	576	524	157	137
Potassium sulfate	13	15	4	2
Potassium nitrate 2/	11	15	5	3
Total 1/	600	554	166	142
Mixed fertilizers	18	19	2	11
Total 1/	1,235	1,385	364	318

na = Not available. # = Less than $500,000.

1/ Totals may not add due to rounding. 2/ Includes potassium sodium nitrate.

Source: (7).

Appendix table 2--Plant nutrient use by State for years ending June 30 1/

State region	1988 Nitrogen	1988 Phosphate	1988 Potash	1989 Nitrogen	1989 Phosphate	1989 Potash
	1,000 nutrient tons					
Maine	11	9	10	12	11	11
New Hampshire	2	1	2	3	1	2
Vermont	4	3	6	4	4	5
Massachusetts	12	6	8	9	4	5
Rhode Island	2	1	1	2	1	1
Connecticut	3	1	1	5	2	3
New York	76	61	90	77	61	91
New Jersey	25	12	16	27	14	19
Pennsylvania	74	55	58	71	53	56
Delaware	16	6	12	17	6	14
Maryland	53	37	45	85	31	25
NORTHEAST..................	278	193	249	313	188	232
Michigan	233	126	222	221	118	226
Wisconsin	244	130	309	230	125	314
Minnesota	576	249	321	561	235	312
LAKE STATES................	1,053	505	852	1,011	477	852
Ohio	333	175	325	306	171	276
Indiana	434	227	384	447	218	358
Illinois	938	394	693	952	384	622
Iowa	921	338	480	934	304	465
Missouri	364	169	244	402	176	253
CORN BELT..................	2,991	1,303	2,126	3,041	1,254	1,974
North Dakota	284	139	30	209	138	26
South Dakota	196	79	20	196	86	20
Nebraska	684	126	31	722	146	37
Kansas	573	142	41	553	151	46
NORTHERN PLAINS............	1,737	486	121	1,680	522	129
Virginia	78	56	74	79	55	75
West Virginia	7	8	8	8	8	8
North Carolina	181	91	163	198	99	182
Kentucky	170	108	130	179	104	128
Tennessee	156	107	131	148	94	112
APPALACHIA.................	592	370	506	613	361	506
South Carolina	78	32	67	77	34	69
Georgia	191	95	145	207	107	156
Florida	229	95	246	246	98	261
Alabama	116	58	73	113	58	71
SOUTHEAST..................	614	280	531	643	297	558
Mississippi	156	47	66	165	47	63
Arkansas	219	57	88	243	60	84
Louisiana	148	50	63	152	47	65
DELTA STATES...............	523	153	217	560	154	212
Oklahoma	306	95	34	349	104	32
Texas	898	229	107	868	238	117
SOUTHERN PLAINS............	1,204	324	140	1,217	342	149
Montana	98	59	13	93	66	12
Idaho	159	64	14	177	75	[illegible]
Wyoming	14	3	0	20	6	1
Colorado	167	49	11	181	49	18
New Mexico	32	11	4	36	13	6
Arizona	84	28	2	90	30	1
Utah	26	12	2	26	12	2
Nevada	3	2	0	4	3	0
MOUNTAIN...................	583	228	46	626	253	53
Washington	197	51	39	198	46	28
Oregon	131	37	29	143	40	26
California	577	183	85	554	174	83
PACIFIC....................	905	271	153	896	260	137
48 States and D.C............	10,479	4,113	4,942	10,600	4,109	4,802
Alaska	2	1	1	3	1	0
Hawaii	17	9	18	17	9	18
Puerto Rico	13	5	12	14	6	12
U.S. TOTAL.................	10,512	4,129	4,973	10,633	4,124	4,832

1/ Totals may not add due to rounding.

Source: (3).

Reliability of Estimates

Fertilizer application rates reported in appendix tables 3-7 are based on farm surveys taken in June, July, and August. These surveys are subject to the sampling and nonsampling errors common to all surveys.

To assist users in evaluating the reliability of the fertilizer application rate estimates, a coefficient of variation (CV) was calculated. The CV is computed by dividing the standard error of the estimate by its mean, and is expressed as a percent. One * indicates that the CV is greater than 10 percent, and two **'s indicate that the CV is greater than 20 percent.

For example, the per acre average nitrogen application rate for corn in 10 states was estimated at 131 pounds with a CV of 1 percent. This means that chances are 2 out of 3 that nitrogen use per acre will not be greater than 132.3 or less than 129.7 pounds. A higher CV indicates greater variability in the estimate. Indiana's P205 application rate per acre for soybeans was estimated at 48 pounds with a CV of 13 percent. Chances are 2 out of 3 that the P205 use per acre will not be greater than 54.2 pounds nor less than 41.8 pounds. In the case of Missouri's per acre nitrogen use on soybeans, the mean was estimated at 25 pounds with a CV of 37 percent, which translates into a range for the true mean of between 15.8 and 34.3 pounds, 2 times out of 3.

Appendix table 3--Fertilizer use on corn for grain, 1989

State	Acres planted	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds			Percent		
Illinois	10,900	234	99	99	83	85	160	74	101	80	1	19
Indiana	5,500	157	99	99	94	87	133	78	110	53	2	45
Iowa	12,700	218	100	99	85	83	128	57	69	87	1	12
Michigan	2,300	77	99	99	94	90	111	52	105	39	4	57
Minnesota	6,200	191	97	97	89	85	115	49	63	79	2	19
Missouri	2,400	111	97	97	79	82	140	58	72	85	3	12
Nebraska	7,500	190	96	96	68	28	145	36	23 *	75	3	22
Ohio	3,400	152	100	99	97	92	143	72	101	50	2	48
South Dakota	3,400	117	69	69	58	30	69	33	23 *	89	6	5
Wisconsin	3,600	147	99	99	95	95	88	55	73	72	1	28
Area	57,900	1,594	97	97	84	75	131	59	81	75	2	23

* = CV greater than 10 percent.

Appendix table 4--Fertilizer use on cotton, 1989

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds			Percent		
Arizona	460	91	95	95	51	3	178	64	#	11	45	44
Arkansas	590	97	95	94	70	71	80	35	62	39	4	57
California	1,069	223	97	97	42	13	123	56	14 *	40	23	37
Louisiana	650	93	100	100	70	72	86	45	55	46	17	37
Mississippi	1,100	160	100	100	54	61	103	49	65	35	13	52
Texas	4,575	482	63	63	53	22	48	37	12 *	73	11	16
Area	8,444	1,146	79	79	54	32	84	43	40	52	15	33

= Insufficient data. * = CV greater than 10 percent.

Appendix table 5--Fertilizer use on rice, 1989

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds			Percent		
Arkansas	1,150	231	99	99	20	23	125	32	45	5	62	33
California	415	132	100	100	82	14	144	51	44 *	79	3	18
Louisiana	520	147	100	100	75	73	109	47	45	6	62	32
Area	2,085	510	99	99	46	33	125	45	45	20	50	30

* = CV greater than 10 percent.

Appendix table 6--Fertilizer use on soybeans, 1989

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds			Percent		
Northern:												
Illinois	8,800	179	34	10	23	33	17 *	54	85	100	0	0
Indiana	4,600	102	43	20	31	41	12 *	48 *	81	98	2	0
Iowa	8,300	148	19	9	16	18	16 *	50	68 *	96	4	0
Minnesota	5,050	111	19	16	17	16	16 **	34	51 *	100	0	0
Missouri	4,400	139	25	11	20	23	25 **	41	69	88	9	3
Nebraska	2,600	85	28	24	28	13	16 *	36 *	23 *	96	0	4
Ohio	4,000	123	51	21	37	50	14 *	55 *	93	98	0	2
Sub-area	37,750	887	30	14	23	28	16	48	77	97	2	1
Southern:												
Arkansas	3,500	129	29	11	27	29	16 **	37	57	95	5	0
Georgia	1,200	76	79	67	77	78	20 *	40	76	97	0	3
Kentucky	1,200	93	55	35	54	55	24 *	63	76	98	0	2
Louisiana	1,950	91	38	8	36	37	24 **	41	60	94	6	0
Mississippi	2,500	96	34	10	34	34	16 **	42 *	63 *	97	3	0
North Carolina	1,550	83	64	54	55	63	24 *	40 *	80	91	8	2
Tennessee	1,480	88	52	22	45	51	21 *	43	61	100	0	0
Sub-area	13,380	658	44	24	42	44	21	43	67	96	3	1
Area	51,130	1,545	34	17	28	32	18	46	74	97	2	1

* = CV greater than 10 percent. ** = CV greater than 20 percent.

Appendix table 7--Fertilizer use on wheat, 1989

State	Acres 1/	Fields in survey	Acres receiving: Any ferti-lizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds			Percent		
Winter wheat:												
Arkansas	1,350	70	97	97	38	38	99	45 *	54	7	63	30
California	570	63	92	92	36	6	105	43 **	#	56	13	31
Colorado	2,100	77	64	64	13	nr	45	32 *	nr	90	8	2
Idaho	810	90	90	90	45	7	92	36	33 **	27	36	37
Illinois	1,800	67	98	98	78	66	90	72	79	15	23	62
Indiana	880	61	95	95	89	88	76	63 *	65	20	9	71
Kansas	9,600	233	87	87	52	6	53	32	29 **	73	5	22
Missouri	1,850	76	96	96	76	70	86	54	67	16	20	64
Montana	1,700	75	72	72	65	12	34 *	20	8 *	76	2	22
Nebraska	2,050	90	76	76	13	nr	41	30	nr	87	11	2
Ohio	1,200	60	95	95	92	90	79	60	67	13	7	80
Oklahoma	5,700	156	95	95	59	12	75	36	22 **	40	9	51
Oregon	800	84	97	97	12	6	75	44 **	38 **	66	16	18
Texas	3,000	131	72	72	32	8	89	41	26 *	63	8	29
Washington	1,300	115	98	98	41	2	66	30 *	#	82	3	15
Area	34,710	1,448	87	87	50	19	69	42	56	53	12	35
Spring wheat:												
Idaho	580	52	90	90	48	8	99	48	#	75	6	19
Minnesota	2,600	75	99	99	89	65	72	37	28 *	95	0	5
Montana	3,500	63	52	52	46	10	33 *	24 *	15 **	97	3	0
North Dakota	7,700	115	74	74	62	11	44	29	20 *	98	1	1
South Dakota	2,200	52	44	44	35	6	54	28 *	#	91	9	0
Area	16,580	357	70	70	59	19	52	30	24 *	95	2	3
Durum wheat:												
North Dakota	3,000	134	70	70	60	3	33	26	#	98	2	0
All wheat 2/												
Arkansas	1,350	70	97	97	38	38	99	45 *	54	7	63	30
California	570	63	92	92	36	6	105	43 **	#	56	13	31
Colorado	2,100	77	64	64	13	nr	45	32 *	nr	90	8	2
Idaho	1,390	142	90	90	47	7	95	41	32 **	47	23	30
Illinois	1,800	67	98	98	78	66	90	72	79	15	23	62
Indiana	880	61	95	95	89	88	76	63 *	65	20	9	71
Kansas	9,600	233	87	87	52	6	53	32	29 **	73	5	22
Minnesota	2,600	75	99	99	89	65	72	37	28 *	95	0	5
Missouri	1,850	76	96	96	76	70	86	54	67	16	20	64
Montana	5,200	138	59	59	52	10	34 *	26	12 **	88	2	9
Nebraska	2,050	90	76	76	13	nr	41	30	nr	87	11	2
North Dakota	10,700	249	73	73	61	9	41	28	19 *	98	1	1
Ohio	1,200	60	95	95	92	90	79	60	67	13	7	80
Oklahoma	5,700	156	95	95	59	12	75	36	22 **	40	9	51
Oregon	800	84	97	97	12	6	75	44 **	38 **	66	16	18
South Dakota	2,200	52	44	44	35	6	54	28 *	#	91	9	0
Texas	3,000	131	72	72	32	8	89	41	26 *	63	8	29
Washington	1,300	115	98	98	41	2	66	30 *	#	82	3	15
Area	54,290	1,939	81	81	53	18	62	37	46	67	9	24

* = CV greater than 10 percent. ** = CV greater than 20 percent.
# = Insufficient data. nr = None reported.

1/ Acres are harvested for winter wheat and planted for all other crops. 2/ Does not include winter wheat in MN, ND, and SD; spring wheat in CA, CO, and WA; or durum wheat in MN, MT, and SD.

Appendix table 8--Projected world supply-demand balances of plant nutrients for years ending June 30

World regions	Nitrogen		Phosphate		Potash	
	1989	1994	1989	1994	1989	1994
	Million metric tons					
Developed market economies:						
Supply	21.97	21.98	18.28	18.48	16.38	16.56
Demand	23.93	24.04	11.83	12.02	11.42	11.80
Balance	-1.96	-2.06	6.45	6.46	4.96	4.76
North America--						
Supply	11.30	11.36	10.03	10.55	10.00	10.00
Demand	11.30	11.54	4.60	4.72	5.01	5.35
Balance	-0.00	-0.18	5.43	5.83	4.99	4.65
Western Europe--						
Supply	9.28	9.36	5.39	5.00	5.18	5.25
Demand	11.10	10.85	5.00	4.91	5.42	5.40
Balance	-1.82	-1.49	0.39	0.09	-0.25	-0.15
Oceania--						
Supply	0.35	0.34	1.21	1.27	0.00	0.00
Demand	0.43	0.50	1.17	1.27	0.24	0.29
Balance	-0.08	-0.16	0.04	-0.00	-0.24	-0.29
Other countries--						
Supply	1.04	0.92	1.66	1.67	1.20	1.31
Demand	1.10	1.15	1.06	1.12	0.75	0.76
Balance	-0.06	-0.23	0.60	0.55	0.45	0.55
Developing market economies:						
Supply	18.14	22.74	9.33	10.56	0.78	1.04
Demand	20.05	25.11	9.53	11.68	4.82	5.84
Balance	-1.91	-2.37	-0.20	-1.12	-4.04	-4.80
Africa--						
Supply	0.52	0.68	4.02	4.61	0.00	0.00
Demand	0.90	1.15	0.70	0.85	0.31	0.40
Balance	-0.38	-0.47	3.32	3.76	-0.31	-0.40
Latin America--						
Supply	4.08	4.71	1.91	2.02	0.04	0.07
Demand	4.13	4.85	2.92	3.28	2.15	2.57
Balance	-0.05	-0.14	-1.01	-1.26	-2.11	-2.50
Near East--						
Supply	4.09	5.62	1.44	1.68	0.74	0.97
Demand	3.02	3.91	1.61	2.25	0.16	0.22
Balance	1.07	1.71	-0.17	-0.57	0.58	0.75
Far East--						
Supply	9.45	11.73	1.96	2.25	0.00	0.00
Demand	12.00	15.20	4.30	5.30	2.20	2.65
Balance	-2.55	-3.47	-2.34	-3.05	-2.20	-2.65
Centrally planned countries of Asia:						
Supply	14.70	16.59	3.28	3.75	0.03	0.08
Demand	18.00	19.90	5.00	6.00	1.40	1.88
Balance	-3.30	-3.31	-1.72	-2.25	-1.37	-1.80
Eastern Europe and the USSR:						
Supply	25.10	26.34	9.72	10.68	13.56	14.18
Demand	16.50	18.50	11.70	12.94	10.05	10.55
Balance	8.60	7.84	-1.98	-2.26	3.51	3.63
WORLD TOTAL:						
Supply	79.90	87.64	40.61	43.48	30.74	31.86
Demand	78.48	87.55	38.06	42.64	27.69	30.07
Balance	1.42	0.09	2.55	0.84	3.05	1.79

Source: (4).

Appendix table 9--Selected herbicides used in corn production, 1989

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Area
						Thousand					
Acres planted	10900	5500	12700	2300	6200	2400	7500	3300	3400	3600	57800
Acres with herbicides	10853	5360	12642	2151	6005	2270	7275	3213	2848	3355	55972
						Percent					
Proportion treated	100	97	100	94	97	95	97	97	84	93	97
Treated acres by active ingredient:											
Single materials--											
Alachlor	9	5	16	1	21	7	10	1	20	7	12
Atrazine	11	6	5	8	3	17	13	6	4	23	9
Bromoxynil	2	1	5	nr	4	3	1	nr	3	1	2
Cyanazine	nr	2	5	nr	5	3	6	1	1	5	3
Dicamba	5	5	9	7	25	1	4	nr	15	8	9
EPTC	2	1	14	7	21	1	3	3	29	4	8
Metolachlor	15	2	21	6	14	1	2	3	7	5	11
2,4-D	10	5	9	1	12	3	9	nr	9	4	8
Other	8	6	8	4	11	3	9	34	15	12	9
Combinations--											
Atrazine + alachlor	16	35	7	26	4	22	21	nr	2	13	15
Atrazine + bromoxynil	2	1	9	3	3	2	1	14	2	nr	3
Atrazine + butylate	8	11	0	4	nr	7	3	nr	nr	1	4
Atrazine + cyanazine	8	9	9	6	1	13	7	nr	1	2	7
Atrazine + dicamba	13	3	4	1	7	1	2	1	2	1	6
Atrazine + metolachlor	16	13	6	17	1	13	16	nr	3	7	11
Atrazine + others	5	2	4	7	3	4	3	46	nr	9	4
Alachlor + cyanazine	1	1	4	6	2	nr	2	5	nr	4	2
Dicamba + 2,4-D	3	2	7	nr	6	nr	1	3	9	1	4
Other 2-way mixes	3	2	6	6	11	5	9	5	2	9	5
3-way mixes	4	9	7	10	8	8	3	12	4	14	7
Average acre-treatments	1.42	1.21	1.54	1.19	1.61	1.12	1.21	1.34	1.30	1.31	1.38

nr = None reported.

Appendix table 10--Selected herbicides used in northern soybean production, 1989

Item	IL	IN	IA	MN	MO	NE	OH	Area
					Thousand			
Acres planted	8800	4600	8300	5050	4400	2600	4000	37750
Acres with herbicides	8702	4420	8244	5050	3988	2508	3870	36782
					Percent			
Proportion treated	99	96	99	100	91	96	97	97
Treated acres by active ingredient:								
Single materials--								
Aciflurofen	3	2	1	3	nr	nr	3	2
Alachlor	1	5	3	6	3	2	6	3
Bentazon	27	7	15	22	4	10	4	15
Chloramben	2	1	3	7	1	nr	3	3
Chlorimuron	2	6	5	nr	14	2	1	4
Dimethazone	2	2	3	nr	2	2	2	2
Ethalfluralin	7	3	5	14	nr	4	nr	5
Fluazifop	2	1	nr	3	3	11	3	2
Glyphosate	nr	1	2	2	1	1	1	1
Imazaquin	2	1	nr	1	6	1	1	2
Imazethapyr	3	2	10	19	3	7	4	7
Metolachlor	5	3	1	1	1	nr	5	2
Metribuzin	1	4	4	1	2	5	2	2
Pendimethalin	7	nr	7	2	1	6	nr	4
Sethoxydim	1	3	4	3	4	nr	1	2
Trifluralin	24	8	39	40	21	22	1	25
Other	5	13	5	8	3	11	6	7
Combinations--								
Trifluralin + dimethazone	4	1	7	3	2	9	2	4
Trifluralin + imazaquin	5	7	1	nr	13	4	nr	4
Trifluralin + metribuzin	5	2	7	5	2	6	3	5
Aciflurofen + bentazon	4	3	6	12	nr	2	3	5
Alachlor + linuron	2	8	nr	1	1	1	6	2
Alachlor + metribuzin	1	5	1	2	nr	1	11	2
Metolachlor + metribuzin	2	7	1	nr	1	2	17	4
Pendimethalin + imazaquin	8	3	1	nr	13	4	1	4
Other 2-way mixes	15	23	14	18	17	9	31	16
3-way mixes	14	8	10	5	19	9	9	11
Average acre-treatments	1.53	1.32	1.55	1.77	1.38	1.32	1.22	1.48

nr = None reported.

Appendix table 11--Selected herbicides used in southern soybean production, 1989

Item	AR	GA	KY	LA	MS	NC	TN	Area
					Thousand			
Acres planted	3500	1200	1200	1950	2500	1550	1480	13380
Acres with herbicides	3229	1062	1161	1779	2240	1457	1480	12408
					Percent			
Proportion treated	92	89	97	91	90	94	100	93
Treated acres by active ingredient:								
Single materials--								
Aciflurofin	9	nr	2	8	2	nr	5	5
Alachlor	4	7	6	5	nr	12	nr	4
Bentazon	10	4	6	2	2	4	8	6
Chlorimuron	2	12	2	24	19	5	7	10
Dimethazone	2	nr	1	7	1	1	nr	2
Fluazifop	3	4	12	13	5	1	16	7
Glyphosate	3	nr	nr	1	1	1	2	1
Imazaquin	15	3	6	10	9	nr	9	9
Metolachlor	12	1	1	1	3	4	nr	5
Metribuzin	8	9	nr	2	9	nr	1	5
Pendimethalin	8	9	nr	nr	8	4	6	5
Quizalofop	3	nr	3	nr	1	nr	3	2
Sethoxydim	8	1	nr	4	5	1	1	4
Trifluralin	33	22	28	17	35	6	34	26
Other	4	22	12	10	12	8	6	9
Combinations--								
Aciflurofen + bentazon	4	nr	6	1	1	3	2	3
Aciflurofen + naptalam	11	nr	3	1	6	nr	8	5
Alachlor + glyphosate	1	nr	9	nr	nr	10	1	2
Chlorimuron + metribuzin	1	nr	4	6	12	1	2	4
Pendimethalin + imazaquin	9	nr	7	4	8	12	5	7
Trifluralin + imazaquin	13	1	6	10	9	3	9	8
Trifluralin + metribuzin	2	16	nr	5	5	3	6	4
Other 2-way mixes	11	19	31	40	19	36	32	25
3-way mixes	3	9	24	13	10	10	11	10
Average acre-treatments	1.77	1.39	1.69	1.84	1.83	1.24	1.74	1.69

nr = None reported.

Appendix table 12--Selected herbicides used in cotton production, 1989

Item	AR	LA	MS	TX	AZ	CA	Area
				Thousand			
Acres planted	590	650	1100	4575	460	1069	8444
Acres with herbicides	584	650	1093	4163	435	855	7780
				Percent			
Proportion treated	99	100	99	91	95	80	92
Treated acres by active ingredient:							
Single materials--							
Cyanazine	18	18	25	nr	6	12	8
DSMA	10	4	4	nr	nr	nr	2
Fluazifop-butyl	3	10	6	1	3	nr	3
Fluometuron	58	81	49	nr	nr	1	18
Methazole	3	12	4	1	nr	nr	2
MSMA	6	20	8	1	nr	nr	4
Norflurazon	10	18	20	nr	nr	nr	5
Pendimethalin	7	20	4	16	30	35	17
Prometryn	8	6	10	13	23	11	12
Trifluralin	18	43	30	87	23	60	63
Other	18	18	4	2	2	8	6
Combinations--							
Cyanazine + MSMA	21	9	13	nr	2	nr	4
Fluometuron + MSMA	13	18	11	nr	nr	nr	4
Fluometuron + norflurazon	15	9	20	nr	nr	nr	5
Methazole + MSMA	5	14	7	nr	nr	nr	3
Pendimethalin + norflurazon	6	8	5	nr	nr	nr	2
Prometryn + MSMA	23	31	21	nr	1	nr	7
Trifluralin + norflurazon	25	17	33	nr	nr	nr	8
Trifluralin + prometryn	1	nr	nr	2	28	1	3
Other 2-way mixes	21	28	36	3	21	nr	12
3-way mixes	9	1	10	nr	nr	nr	2
Average acre-treatments	2.99	3.86	3.21	1.26	1.41	1.27	1.89

nr = None reported.

Appendix table 13--Selected herbicides used in winter wheat production, 1989

Item	CA	CO	ID	KS	MT	NE	OK	OR	TX	WA	Area
						Thousand					
Acres planted	570	2100	810	9600	1700	2050	5700	800	3000	1300	27630
Acres with herbicides	404	440	728	2446	1358	573	2054	790	791	1119	10703
						Percent					
Proportion treated	71	21	90	25	80	28	36	99	26	86	39
Treated acres by active ingredient:											
Single materials--											
2,4-D	57	46	42	24	35	59	31	15	49	14	32
Chlorsulfuron	nr	nr	3	45	15	nr	59	10	38	1	27
Dicamba	nr	nr	nr	13	nr	nr	nr	3	4	nr	3
MCPA	25	nr	nr	2	2	nr	2	8	nr	2	3
Metsulfuron	nr	50	1	nr	10	4	2	nr	nr	nr	4
Other	26	6	14	nr	3	13	nr	24	nr	15	7
Combinations--											
2,4-D + chlorsulfuron	nr	nr	nr	3	2	nr	5	13	4	2	3
2,4-D + dicamba	6	nr	5	6	3	19	nr	5	nr	2	4
2,4-D + glyphosate	nr	6	nr	7	nr	nr	nr	8	13	1	3
2,4-D + metsulfuron	nr	12	nr	6	14	5	nr	nr	nr	nr	4
Chlorsulfuron + metsulfuron	nr	nr	5	2	nr	nr	nr	4	nr	6	2
Other 2-way mixes	5	6	27	7	23	nr	5	18	2	29	12
3-way mixes	2	nr	10	2	2	nr	nr	27	2	36	7
Average acre-treatments	1.22	1.26	1.07	1.14	1.08	1.00	1.03	1.36	1.13	1.08	1.12

nr = None reported.

Appendix table 14--Selected herbicides used in spring wheat production, 1989

Item	Spring wheat ID	MN	MT	ND	SD	Area	Durum ND
	Thousand						
Acres planted	580	2600	3500	7700	2200	16580	3000
Acres with herbicides	480	2463	3222	7231	1650	15046	2866
	Percent						
Proportion treated	83	95	92	94	75	91	96
Treated acres by active ingredient:							
Single materials--							
2,4-D	60	20	28	33	23	30	31
MCPA	2	18	3	12	13	11	10
Chlorsulfuron	nr	nr	nr	3	nr	1	2
Dicamba	nr	nr	nr	3	5	2	5
Diclofop-methyl	2	14	nr	7	nr	6	8
DPX-M6316	nr	6	nr	6	5	5	2
Metsulfuron	nr	nr	5	2	15	4	6
Triallate	2	6	3	2	nr	3	3
Trifluralin	nr	6	nr	12	3	7	30
Other	5	4	nr	5	5	4	6
Combinations--							
2,4-D + chlorsulfuron	nr	nr	7	nr	nr	1	3
2,4-D + dicamba	9	3	22	8	23	12	11
2,4-D + metsulfuron	nr	nr	28	2	nr	7	8
MCPA + bromoxynil	5	24	nr	2	5	6	2
MCPA + dicamba	nr	4	3	17	3	10	8
Triallate + trifluralin	nr	nr	nr	1	nr	nr	2
Other	23	24	9	13	8	14	12
Average acre-treatments	1.09	1.28	1.09	1.28	1.08	1.21	1.48

nr = None reported.

List of Tables

Page

Appendix tables:

Special articles:

Recent Updates in Farmland Values

In a January 1990 survey, a national panel of 485 accredited rural appraisers provided information on recent and anticipated changes in farmland values. Their responses pertained to their specific areas, but were weighted to form national and four regional estimates.

Most appraisers reported that farmland values increased over the January 1989-90 period. At the national level, 77 percent reported a rise in land values, with average values climbing 4.8 percent. About 14 percent of the appraisers indicated land values did not change; 9 percent indicated a decrease. All regional values averaged higher over the past 12 months, with a 6.8-percent increase in the North Central region, a 4.2-percent gain in the West and Northeast regions, and a 3.0-percent rise in the South. When asked to explain the increases, the appraisers most frequently cited relatively high commodity prices, including those for livestock.

The majority of appraisers--65 percent--reported no change in farmland values over the October-December 1989 period. But 34 percent reported an increase, while only 1 percent reported a decrease. The distribution of directional changes that appraisers observed closely resembles the changes they forecast in October 1989. The average forecast called for U.S. farmland values to increase 1.2 percent. In the January 1990 survey, the reported value increase for the last quarter was 1.1 percent.

The most frequently cited reasons for the increase over the last quarter of 1989 were relatively high commodity prices and the farmers' heightened demand for land. In the Northeast, however, appraisers attributed the increase primarily to greater investment demand by nonfarmers.

The appraisers provided forecasts of farmland value changes over the next 3- and 12-month periods. In the first quarter of 1990, 31 percent expect values to increase, 66 percent expect no change, and 3 percent anticipate a decrease. Overall, the forecast rise in values is 0.7 percent, with the largest forecast increases in the Northeast and North Central regions (1.4 percent and 0.9 percent, respectively).

Looking ahead for the calendar year 1990, 67 percent of the appraisers expect values to increase, 28 percent expect no change, and 5 percent expect a decrease. The average expected rise in U.S. farmland values is 3.1 percent. Relatively larger increases of 6.8 percent are expected in the Northeast, while the smallest increases are expected in the North Central region, at 2.5 percent. Appraisers identified anticipated high commodity prices and anticipated strong expansion demand for land as the most important reasons for the increases in both periods.

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